Study of Breach parameters & Flood inundation mapping for Gunta Nala Dam using HEC-RAS model

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SUBMITTED BY:

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This is to certify that, the thesis is conducted by **Er. Gireesh Chandra (17MTAEID019)** as reported in the present work was compiled under my guidance and supervision. The results reported by him are genuine and script of thesis has been written by the candidate himself. His thesis entitled **"Study of Breach parameters & Flood inundation mapping for Gunta Nala Dam using HEC-RAS model"** is therefore, being forwarded for the acceptance in the partial fulfillment of requirement for the Degree of **Master of Technology in Agricultural Engineering (Irrigation & Drainage Engineering) at the Vaugh Institute of Agricultural Engineering & Technology** from **Sam Higginbottom University of Agriculture, Technology and Sciences Allahabad, Prayagraj.**

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This is to certify that, I have personally worked on the research thesis entitled**"Study of Breach parameters & Flood inundation mapping for Gunta Nala Dam using HEC-RAS model"** The data mentioned in this report were obtained during the unfeigned work done and collection by myself. Any other data or information in this report which has been collected or borrowed from outside agency has been duly acknowledged. None of the findings /information pertaining to work has been concealed. The results embodied in this project report have been submitted to any other universities or institute for the award of any degree.

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ABSTRACT

The present study was conducted with the prime objective to **Study of Breach parameters & Flood inundation mapping for Gunta Nala Dam using HEC-RAS model**, of Uttar Pradesh State. Gunta Nala Dam was constructed in 1974 for the purpose of irrigation, fishery and drinking water with 25.4 m height and 5700m crest length. Gunta Nala dam is earthen dam with spillway. There are different economic developments downstream of the Gunta Nala dam including irrigation project, residential house. These economic developments are affected either dam break by overtopping or piping mode of failure.

Modeling dam overtopping & piping and flood routing downstream of reservoirs can provide basic information about the magnitudes of flood events that can be beneficial in dam engineering, emergency action planning (EAP), and floodplain management. In recent years there has been considerable progress in computer model code development, computing speed and capability, and available elevation, vegetation, soil type, and land use data which has led to much interest in multi-dimensional modeling of dam failure, overtopping and piping.

The Hydrologic Engineering Center's River Analysis System (HEC-RAS) can be to develop a dam failure model. Arcmap and Google Earth Explorer was used to extract geometric information from a Digital Elevation Model (DEM) and then imported into HEC-RAS 5.0.3 where Unsteady-flow simulation of the dam breach performed. The simulation results were mapped using the RAS Mapper on HEC-RAS. Inundation mapping of water surface profile results from dam failure models provides a level of the flood hazard and provides insight for emergency action plan.

The process for gathering and preparing data, estimating breach parameters, creating an unsteady-flow model in HEC-RAS, entry of dam breach parameters, performing a dam failure analysis for Gunta dam, mapping of the flood inundation is discussed in this thesis work.

Key Words: Dam Breach, Modelling, DEM, RAS Mapper, HEC-RAS, Hydrograph, Inundation map

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LIST OF ABBREVIATION

HEC-RAS	*:*	*Hydraulic Engineering Center's River Analysis System*
USACE	:	United States of Army Corps of Engineering
DEM	:	Digital Elevation Model
MWF	:	Maximum water level
EAP	:	Emergency Action Plan
PMF	:	Probable maximum flood
GIS	:	Geographic Information System
Mha	:	Million hectares
A_s	*:*	*Surface area of the reservoir*
B_{avg}	:	Average Breach Width
C	:	Width of the dam crest in meter
C_b	:	Coefficient, which is a function of reservoir size
H_b	:	Height of Breach in Meter
H_w	:	Maximum depth of water stored behind the breach
V_w	:	Reservoir Volume Stored Behind the dam
Q_p	:	Dam Breach Peak Discharge
T_f	:	Breach development time
V_{out}	:	Breach Outflow (m^3)
V_{er}	:	Volume of dam eroded in cubic meters during a breach.
W_b	:	Breach bottom width
Z_b	:	Side slopes of breach (Z_b Horizontal: 1 Vertical)
km^2	:	kilo meter square
ha	:	Hectare
K_o	:	Failure mode factor
m	:	meter
mm	:	millimeter
m^3	:	cubic meter
m^3/s	:	Cubic meter per second

CHAPTER - 1

INTRODUCTION

1.1. Background

Dams are hydraulic structures used to store, control, divert water impounding it behind the upstream side of dam in a reservoir for different purposes, like hydropower generation, water supply, irrigation, navigation and transportation, etc. Although dams have many advantages, the risk that may happen due to the failure still exists. Dams can have a risk to downstream communities and properties if not designed, operated and maintained properly. Dams are classified as concrete dams or earthen dams depending on construction materials, large and small dams depending on water storage volume behind the dam and height of the dam.

But also, hundreds of dams have failed due to high flows in the river, and inflow in reservoir etc. In India the worst dam disaster occurred in Machhu II dam was constructed to serve an irrigation scheme (Gujarat, 1972-1979). This dam failed because of excess flood, inadequate capacity of spillway and due to overtopping of water over embankment dam in August 1, 1979. Kaddam Dam was failed due to overtopping of water above the crest by 46cm and due to this mode of failure 137.2m of breach width has been developed on the left bank in August 1958 (Andhra Pradesh). The world's worst dam failure "Banqiao Dam and the Shimantan Dam" occurred due to the overtopping in August 1975 and around 85,000 peoples were died by flooding in China (Sachin, 2014). However, we have to give deep attention for breaking of embankment dams comparing with other types of dams because the floods resulting from the failure of constructed dams produced some of the most devastating disaster of the last centuries. Simulation of dam break result and resulting floods are essential for characterizing and reducing negative effects occurred on the downstream area. Development of emergency action plan requires exact estimation of inundation level and the arrival time of flood wave at the downstream points. The breakage frequencies of earth dams are almost four times greater than concrete dams or masonries (Shahraki et al., 2012).

Dam failure results due to external force and internal erosion. The USACE Hydrologic Engineering center (HEC) research document lists 13 dam failure causes as: 1) earth quake 2) land slide 3) extreme storm 4) piping 5) equipment malfunctioning 6) structure Damage

7) foundation failure 8) overtopping and etc (Xiong, 2011). Breach is defined as the opening formed in the dam body that causes the water to spread to the downstream location. Different Case studies show that dam failure may arise due to different reasons ranging from seepage, piping (internal erosion), overtopping due to insufficient free board and settlement due to side slopes on the upstream shells and liquefaction due to earthquakes.

All dams, regardless of their design or construction, have increased forces applied to them during extreme events which increase the potential risk of failure (Ahmad Asnaashari, 2014). Therefore, a dam breach analysis is usually conducted to determine the ultimate discharge from a hypothetical breach of a dam under such events. The outcome is a breach hydrograph from dam failure with a flood wave immediately downstream of the dam, which is routed throughout the river system to determine the flood arrival time, peak flow, and the depth of flow at downstream locations.

Generally, modeling of a potential embankment-breaching failure involves solving two problems, i.e., determining the outflow from the breach and routing the computed flood wave through the downstream flood plain (ChaiyuthChinnarasri, 2007)

This study discusses the dam failure analysis of a medium earth dam. As a case study, Gunta Nala Dam which is located about 26 km from Karwi,Chitrakoot near Raipura village. Crest length of dam is 5.7 km and maximum storage depth of dam is 25.4 m (bottom elevation 100 m and top elevation of dam is 125.5m).

This dam can be classified as high hazard structure since the size of number of population is significant and property found at downstream of the dam is very large. Due to this classification, modeling the dam breach and analyzing the effect of dam breach outflow hydrograph on downstream floodplain for this dam is necessary.

1.2. Statement of the Problem

A well-designed, constructed, and operated dam can reduce flood risk in downstream areas by temporarily impounding flood waters and attenuating the observed peak flood flows in exposed low lying areas, even if the dam is not specifically designed for flood mitigation. However, impounding water behind a dam also creates risk to downstream areas because of the potential for uncontrolled release of the reservoir pool caused by dam failure which could result in a peak flow discharge that greatly exceeds any possible natural flood event. There are several potential causes of dam failure including hydrologic, hydraulic, geologic, mechanical, and operational (FEMA, 2013).

One of the most common causes of dam failures is the inability to safely pass flood flows. Failures caused by hydrologic conditions can range from sudden failure, with complete breaching or collapse of the dam, to gradual failure, with progressive erosion and partial breaching (FEMA, 2013)

Dam failures may occur due to a variety of causes such as significant hydrologic and non-hydrologic events. If a dam breach occurs, an uncontrolled release of water impounded behind the structure will cause flooding in the downstream area and affect the population and damages the economic resources. Nowadays, there are many embankment dams existing, under construction and planned to be constructed in India. Therefore, in addition to proper design and construction method, the dam failure and risk analysis must be undertaken for the sake of safety.

Gunta Nala Irrigation Project Dam, an earthen embankment dam consists of impervious clay core has constructed in 1974. This dam is proposed to impound the water within the reservoir of capacity 28.80 million meter cube at its full pool level. The main purpose if this dam is to retain, control and release this water for downstream huge irrigation fields without the disturbance of the downstream natural river flow system. Unlike its benefits, its safety also should be considered for the consequence in case the failure may exist during and after the construction time. At the downstream of Gunta Nala Dam, there is a huge irrigation field of 3886.00 hectares along Gunta canal in right side at a distance of about 32.1 km downstream of the dam. Additionally, two bridge which is located at 0.9 km downstream near Raipura village on Banda-Prayagraj highway and 12.600 km downstream near Chhibon town on Rajapur highway. Some villages are also located downstream like Raipura, Dhan, Chhibon, Atarsui ,PiyariyaMafi, Manaudh, PiyariyaKhurd and Tirmau and etc at about 25.97 km downstream. Even if the spillway of the proposed dam was designed to pass the inflow design flood, the dam breach modeling and downstream risk analysis for the worst hydrologic and non-hydrologic are important for the safety of the dam and to prevent the life loss and property damages may happen in case the failure may occur.

The problem that needs to be solved in this study is the proper modeling of Gunta Nala Dam breach and the effect of the breach outflow flood on the downstream flood plain. Therefore, for the proposed dam breach modeling, prediction of breach outflow hydrograph and computer simulation to evaluate the dam failure and its impact to downstream area, which is the first phase of dam breach analysis, is discussed for dam failure scenarios.

1.2.1 Piping

Piping is a flow of water in porous parts of the dam especially through high permeability regions, cavities, fissures or strata of sand and gravel. Such concentrated flow at hydraulic gradient may erode the soil part of the dam which causes the breakage of the earth dam. Piping through the dam body is caused by: faulty construction, insufficient compaction, cracks in the embankment due to foundation settlement, animal borrows pipes and conduits inside the dam body. (Jabir, 2013).

1.2.2 Overtopping

Overtopping is defined as uncontrolled flow of water over the crest of the dam. Overtopping may lead to failure of the dam due to excessive erosion of downstream slope. The main causes of overtopping are: under estimation of the design flood and inadequate spillway capacity, large andrapid landslides in the reservoir, insufficient free board and malfunctioning of the spillway gates. (Jabir, 2013).

The three primary tasks in Dam Break Analysis are: calculation of dam breach parameters, calculate peak outflows for overtopping and piping failure approaches, estimation of inundation levels and damages to downstream structures. Many models have been developed before few years for dam break analysis such as HEC-RAS Model, FLDWAV, SMPDBK, and DAMBRK etc (Altinakar, 2008).

1.3. HEC-RAS 5.0.3

HEC-RAS is based on the U.S. Army Corps of Engineers' HEC-RAS water surface profile model used for modeling both steady and unsteady, one-dimensional, gradually varied flow in both natural and man-made river channels. GIS approach for automated floodplain mapping to aid in the design of drainage facilities. The approach establishes a connection between the HEC-RAS hydraulic model and Arc view GIS, allowing for improved visualization and analysis of floodplain data. It also permits GIS to function as an effective planning tool by making hydraulic data easily transferable to floodplain management, flood insurance rate determination, economic impact analysis, and flood warning systems. Flood inundation maps created by HEC-RAS for the 1-10-year flood events. HEC-RAS and its companion GIS extension HEC-GeoRAS can aid in the development of flood inundation maps. HEC-RAS is a powerful, yet easy-to-use software package for determining water surface profiles in a wide variety of streams.

1.4. Objective

The main objective of this study is to model the Gunta Nala Earthen Dam breach and analyze the risk level (consequence) due to the dam breach/failure on the downstream floodplain.

The specific objectives are:

- To calculate dam breach parameters and peak outflows for piping and overtopping failure
- To route the model outflow hydrographs through the downstream floodplain.
- To prepare floodplain inundation maps to give a response in order to prevent or reduce the damages that may occur on downstream due to the dam failure.

CHAPTER - 2

REVIEW OF LITERETURE

Chongxun(2008)in this paper, a model of overtopping risk under the joint effects of floods and wind waves, which is based on risk analysis theory and takes into account the uncertainties of floods, wind waves, reservoir capacity and discharge capacity of the spillway, is proposed and applied to the Chengbihe Reservoir in Baise City in Guangxi Zhuang Autonomous Region. The simulated results indicate that the flood control limiting level can be raised by 0.40 m under the condition that the reservoir overtopping risk is controlled within a mean variance of 5×10-6. As a result, the reservoir storage will increase to 16 million m3 and electrical energy generation and other functions of the reservoir will also increase greatly.

Carling (2009)one of the largest known floods occurred during the Late Quaternary, emanating from an ice-dammed lake in Asia. Glacial lake Kuray–Chuja was formed by a 600-m-high ice dam converging in the Chuja River valley of the Altai Mountains in southern Siberia. The dam impounded up to 594 km3 of water in the Kuray and Chuja basins. At least three floods from lakeKuray–Chuja occurred, but only the largest, or the most recent, is modeled herein. The discharge, through an ice dam breach by tunneling or over-topping, is analyzed using dam breach equations including one specifically developed for ice dam failures. From these calculations it is concluded that the ice dam need not have failed when the water was at a maximum depth (i.e. 600 m deep) but, in consideration with flood routing models, it is probable that the lake emptied by over-topping under conditions of maximum water level. Although an over-topping model is favored, a collapse of the ice dam due to initial tunnel development in the ice body cannot be precluded.

Xin *et al* (2011) Public pay more and more attention to how to ensure the safety of tailings dam downstream residents and property. This article establishes a risk evaluation system which bases on the tailings dam failure probability analysis and dam failing consequence assessment. The tailings dam failure mode is established through the research of tailings dam failure mechanism. Meanwhile established the tailings dam stability assessment index system, applied the set pair analysis to assessment the stability of the tailings dam; established the controlling equation, simulated the routing and movement of tailing flow in the downstream after tailings dam break, investigated the distributions of personnel and structures in the influence range, use comprehensive factor weighted method to construction the tailings dam break serious consequences evaluation model, the model considered the tailings dam scale, loss of life, economic losses and social environment impact, points out key point and the difficulty of the tailings dam break impact research, the tailings dam for precise quantitative risk assessment is very difficult, the risk assessment index is a kind of qualitative risk analysis methods, established the tailings dam risk assessment software based on risk assessment index methods.

Tiwariand Sharma (2012) Ganga, Kosi, and Damodar-carrying and delivering among the highest sediment loads in the world and Reservoir sedimentation is a serious problem in India. Fluvial processes are governed by the principles of continuity, flow resistance, sediment transport and bank stability. River width adjustment occurs concurrently with changes in river bed profile, slope, channel pattern, roughness, etc. These changes are closely interrelated; they are delicately adjusted to establish or to maintain the dynamic state of equilibrium. The model HEC-RAS delineates a fully functional modeling environment which allows to cope with virtually all types of problems concerning river networks. Sediment transport analysis based on Yang sediment transport function has done(quasi unsteady flow) with the help of 14 years (1994-2008) sediment discharge data and change is predicted.Maximum change is predicted 1.6 km upstream of Dam site and it is in order of 10 m. At the same cross section same occurrence of maximum velocity 6.2 m/s and maximum shear stress 52 N/m2 confirms the reliability of maximum change in invert. As the shear stress has important role on lifting the particle from bed. The extent of sedimentation will still remain restricted below the invert level of the under-sluice gates well within the dead storage zone of the reservoir. According the change in bed level different construction and management practices is suggested.

You*et al* (2012)developmental characteristics of dam-break research on earth-rock dam were reviewed and nowadays researchers emphasized corporation and paid more attention to quantitative description, multiple processes coupling and system integration in research. Combining with most concerned problems in dam safety management (DSM), achievements were reviewed in three fields: causal factors of disasters, dam-break process and flood propagation. In order to perfect a DSM system, researches on variations of dam material properties and corresponding effect in dam-break process, scale effect, similarity criteria of dam-break process and uncertainty analysis of common used models should be enhanced.

Chonghui*et al* (2012) in order to quantitatively forecast failure scope, Xiaozhaizihe Reservoir concrete arch dam is chosen as a dam-break event case in this paper. 3-D solid model is built and elastic-plastic finite element method is used by ANSYS software. The dam work conditions of its water levels, its temperature drop and weight are defined by the early period storage and climatic conditions. The dam-break loads (or forces) of the dam and its base are simulated. Results show that the dam structure is not strong enough, and its design is not meeting the specifications, and the weakest position of dam is at the junction both phase I and phase II of the cold concrete. So it's concluded that the dam-break early occurred where the compressive and tensile strength M-C safety factor is less than 1, and the dam-break end-scope cover the safety factor 2.0 M-C so that people forecast the quantitative failure scope of concrete dam.

Goodarzi*et al* (2012) Hydrologic risk assessment and uncertainty analysis by mathematical and statisticalmethods provide useful information for decision makers. This study presents the application of risk and uncertainty analysis to dam overtopping due to various inflows and wind speeds for the Meijaran Dam in the north of Iran. The procedure includes univariate flood and wind speed frequency analyses, reservoir routing, and integration of wind set-up and run-up to calculate the reservoir water elevation. Afterwards, the probability of overtopping was assessed by applying two uncertainty analysis methods (Monte Carlo simulation and Latin hypercube sampling), and considering the quantile of flood peak discharge, initial depth of water in the reservoir, and spillway discharge coefficient as uncertain variables. The results revealed that rising water level in the reservoir is the most important factor in overtopping risk analysis and that wind speed also has a considerable impact on reservoirs that are placed in windy areas.

Murkowski *et al* (2012) to describe the progress of a hypothetical flood in a watercourse reach, including potential changes in the channel geometry. The quasi-hydrodynamic model employed takes into account changes in the temperature of the medium over time, the complex structure of the watercourse channel, almost any recharge pattern and any engineering structures in the channel. As a result, it is possible to estimate probable changes in the geometry of precisely reproduced reaches of existing watercourse channels during significant floods and include them, e.g., in real-time operational models.

Mohammadi *et al* (2013)The cost of damages due to flooding depends on several factors. However, several methods, using different approaches, can be used to estimate flood damages. In this study, the residential area of Neka river, in the East of Mazandaran province (north of Iran), is considered. The most important part of the river basin is the Neka city that is located in intersection of the foothills and coastal zone (Caspian Sea). According to Francou-Rodier

Formula, this basin is potentially at the high risk of flooding. During past decades, several floods have been observed, resulting in costly property damages and human casualties. Therefore, flood damages need to be estimated basing on different scenarios, to be able to propose engineering optimized options for flood controls and to better manage the subsequent crisis. In this research, using GIS models, HEC-RAS, and HEC-GEORAS software, hydraulic conditions of flood were simulated and flood prone areas were determined for different return periods. Based on the output of this step, using HEC-FDA, a risk analysis was performed and flood damages were estimated quantitatively. Finally, the Expected Annual Damage (EAD) was obtained.

Ros, CheFaizah (2015) Dams have long been acknowledged for providing electricity which is the form of renewable energy, for flood protection, and for making water available for agriculture and human needs. However, the huge amount of energy stored behind the dam results in serious danger to society in case of dam failure. When a dam is breached, catastrophic flooding will occur as the impounded water escapes through the breach and flows into the downstream valley which may cause great devastation in terms of lives lost as well as property damages. The main purpose of the study was to establish dam breach characteristics in prediction of Kenyir outflow hydrograph. Kenyir dam break modelling due to a breach were performed under two scenarios namely Probable Maximum Flood (PMF) scenario and Clear Day scenario. Froehlich and MacDonald &Langridge-Monopolis equations were used in the determination of the dam breach parameters. With the obtained outflow hydrograph, it is possible to see the negative effects by routing it at the downstream. MIKE 11, a very powerful and comprehensive one dimensional model was used. The hydrodynamic module solves the complete nonlinear St. Venant equations for open channel flow. Results obtained from the study indicated that PMF scenario yields higher peak discharge of 412,962 m^3/s compared to the Clear Day scenario, 380,336 m^3/s. The results are reliable since the breach outflow results vary between 24% and 25% for both scenarios compared using Froehlich peak discharge equations.

Georgea et *al*(2015)dams are constructed to serve a variety of purposes such as supply of drinking and irrigation water, generation of electric power, flood protection etc… However a dam break may result in high flood waves traveling along a valley at quite high speed. The intensity of the catastrophic failure of dams varies depending on the extent of inundated area, size of the population under risk and the warning time available. The present study deals with the Dam Break Analysis of Thenmala Dam of Kerala State, India. As a part of the work, the maximum precipitation and maximum flood have been evaluated using the Gumbel’s and

Clark’s method respectively. The final analysis is done using the software BOSS DAMBRK for evaluating the extent of inundation, travel time and velocity of downstream progressing water.

Fondelli*et al* (2015)the numerical simulation of free-surface flows is a vast topic, with applications to various fields of engineering such as aerospace, automotive, nuclear, etc. The Volume of Fluid (VOF) method represents a suitable technique to simulate free surface flows, tracking the air-liquid interface within the calculation domain. However this method requires a very fine mesh to successfully reconstruct the liquid surface, leading to very high computational costs. In this paper, VOF simulations of three-dimensional dam-break problem have been carried out using an adaptive meshing approach. Unsteady calculations have been performed exploiting the adaptive mesh feature implemented in ANSYS Fluent. In particular, a grid adaptation strategy has been defined as a way of significantly reducing the numerical effort. The main idea is to keep high resolution only locally at the air-liquid interface, minimizing numerical diffusion, and to maintain a coarse mesh size elsewhere. The dam-break problem was analyzed because it has been widely studied experimentally and numerically, representing a benchmark problem for verifying numerical models involving free-surface flows. The accuracy of the method has been assessed comparing simulation results with experimental data.

Quiroga*et al* (2016)llanos de Moxos are vast plains in the Bolivian Amazonia that are continually flooded by the Mamoreriver. The flood lasts for several days affecting important cities like Trinidad, drowning people, drowningcattle and swamping arable land. Because of the cloudy skies, remote sensing observations are limitedto some areas and few days. Thus, there is huge uncertainty about characteristics of flood events andpossible consequences. Two-dimensional (2D) numerical simulation proved to be an important tool forunderstanding flood events. The HEC-RAS model is one of the most popular hydraulic models. In 2014 anew version of HEC-RAS (HEC-RAS-v5) was released including 2D capabilities. The present study appliedthe new HEC-RAS-v5 to simulate the February 2014 flood event in the Bolivian Amazonia. The floodsimulated shows good performance when compared with satellite image of the flood event. In addition,the simulation provides information like water depth, flow velocity and a temporal variation of the flood.Specific locations where water begins to overflow were identified. Over most of the flooded area the watervelocity is lower than 0.25 m s^{-1}. During first ten days of the flood the flood extent increases rapidly. Theflood depth allows identifying areas exposed to different hazard levels. The west plain of the Mamoreriver is the most exposed to the flood; it shows bigger flood extent, longer flood duration and deeperwater depth. The flood that threatens the city of Trinidad originates in two locations; one located 32 kmat the north and other located 10 km at the south west. The flood from the north gets close to Trinidadtwelve days after it begins to overflow, while the flood from the south gets close to Trinidad seven daysafter it begins to overflow. Although the flood from the north is deeper than the flood from the south,the flood from the south begins flooded before the north. Thus, water borne and vector borne diseasesmay originate at the south earlier than the north. The city of San Javier gets covered by flood five daysafter the water begins to overflow. The study shows the applicability and the value of the 2D capabilitiesof the new HEC-RAS for flood studies.

Sharmaand Mujumdar (2016) the paper initially describes about the details of the Ajwa Dam and further about the scenario of breaking of Ajwa Dam. The Ajwa Reservoir is located 20 km north-east of Vadodara city with waste weir and outlet works. The major reason of Vadodara being flooded in heavy rains is due to the release of water from Ajwa Reservoir. The attempt is made to study the disaster effect in the event of breaking of Ajwa Dam. Software ArcGIS, HEC-GeoRAS and HEC-RAS are used for the dam break analysis. Prediction of outflow hydrograph at various river station is generated with the help of USACE Hydrologic Engineering Center's River Analysis System software i.e. HEC-RAS. Maximum water surface elevation, velocity in the channel and discharge for a particular station of river in the downstream is described as a result of dam break. Floodplain inundation map is generated for the downstream tail reach.

Escuder-Bueno *et al* (2016)in recent years, risk analysis techniques have proved to be a useful tool to inform dam safety management. This paper summarizes the outcomes of three themes related to dam risk analysis discussed in the Benchmark Workshops organized by the International Commission on Large Dams Technical Committee on "Computational Aspects of Analysis and Design of Dams." In the 2011 Benchmark Workshop, estimation of the probability of failure of a gravity dam for the sliding failure mode was discussed. Next, in 2013, the discussion focused on the computational challenges of the estimation of consequences in dam risk analysis. Finally, in 2015, the probability of sliding and overtopping in an embankment was analyzed. These Benchmark Workshops have allowed a complete review of numerical aspects for dam risk analysis, showing that risk analysis methods are a very useful tool to analyze the risk of dam systems, including downstream consequence assessments and the uncertainty of structural models.

Aishwaryalakshmi *et al* (2017) used inIndia has totally 4050 large dams and 475 are under construction as per the National Register of Large dams 2002. Some of these dams were built in the early 19th century and many during 20thcentury.Every dam need a flood inundation map during the heavy rainfall or dam break for dam operation so the main objective of this paper the flood inundation map was prepared for Sathanur Dam for the maximum discharge of 8000 cumces which was occurred in the year 1973 using HEC-RAS software. The totally capacity of the reservoir is 300.601Mm3.

Lempérière (2017) the possible mitigation of floods by dams and the risk to dams from floods are key problems. The People's Republic of China is now leading world dam construction with great success and efficiency. This paper is devoted to relevant experiences from other countries, with a particular focus on lessons from accidents over the past two centuries and on new solutions. Accidents from floods are analyzed according to the dam's height, storage, dam material, and spillway data. Most of the huge accidents that have been reported occurred for embankments storing over 10 hm3. New solutions appear promising for both dam safety and flood mitigation.

Logah *et al* (2017) the impacts of dam releases from re-operation scenarios of the Akosombo and Kpong hydropower facilities on downstream communities along the Lower Volta River were examined through hydrodynamic modeling using the HEC-RAS hydraulic model. The model was used to simulate surface water elevation along the river reach for specified discharge hydrographs from proposed re-operation dam release scenarios. The morphology of the river and its flood plains together with cross-sectional profiles at selected river sections were mapped and used in the hydrodynamic modelling. In addition, both suspended and bed-load sediment were sampled and analysed to determine the current sediment load of the river and its potential to carry more sediment. The modelling results indicate that large areas downstream of the dam including its flood plains would be inundated if dam releases came close to or exceeded 2300 m3/s. It is therefore recommended to relocate communities along the banks and in the flood plains of the Lower Volta River when dam releases are to exceed 2300 m3/s. Suspended sediment transport was found to be very low in the Lower Volta River and the predominant soil type in the river banks and bed is sandy soil. Thus, the geomorphology of the river can be expected to change considerably with time, particularly for sustained high releases from the Akosombo and Kpong dams. The results obtained from this study form a basis for assessing future sedimentation problems in the Lower Volta River and for underpinning the development of sediment control and management strategies for river basins in Ghana.

Joshi*et al* (2017) dams are beneficial for society but flood occurs due failure of dam is dangerous for lives, properties and Environment. Prediction of dam break flows is necessary for forecasting and evaluation of flooding disaster and preparation of an emergency action plan. In this study dam break flood routing simulation is carried out by using HECRAS two dimensional model for Vir dam to determine Flood Susceptible area at the downstream side of dam. Result will helpful to Local Authority for appropriate planning and development.

Sandhyarekha and Shivapur (2017) show thatnatural hazards are synonym for Floods that influencing severe economic damages and cause impact to human lives. It is always necessary to estimate scenarios of flood for accurate temporal and spatial information on the risks of floods and its potential hazards. This study includes two main objectives; during the worst flood event the flooded area covers, along Krishna River to be calculated and to produce floodplain map of flooded areas. In order to achieve these objectives, the HEC-RAS hydraulic model was used as tools. As a result, the watershed area of the Krishna basin has been successfully modelled and map showing the flooded areas along the part of Krishna basin has been delineated. The floodplain map produced clearly shows the spatial distribution of the flooded area. Generally, high water depth flow along the main channel and spreads gradually to the floodplains. The total flooded area covers at 100 yr. return periods approximately 300 acres near Kudachi and 116 acres near Ugar village along Krishna River. Thus, integration of geospatial process and hydraulic modeling can produce inundation flood map with good accuracy.

Ezza (2017) in the mountainous area of Assiut plateau in southwestern Egypt, a proposed road is designed to pass through a flood path near Durunka village. A reliable and accurate information about natural hazards, could occur in this region especially flash floods, is required. Due to the lack of this information, a runoff model is built adopting the Soil Conservation Service method for an un-gauged watershed of Assiut plateau. The hydrologic characteristics and soil type and cover for the study area are estimated during a site visit. The watershed is delineated and the morphometric parameters are derived from analyzing the SRTM3 Digital Elevation Model (DEM) using Geographic Information System (GIS) to construct a hydrological model. This model provides a good estimate about the magnitude of flash floods including the water velocities and depths using HEC-RAS. Two rainfall events are used in this analysis, the first event is a storm with 50 years return period, and the second event is for highest precipitation value recorded in this area. The model showed that the maximum water depth could occur is 4.01

m and the highest water velocity is 11.75 m/s. The results of this study could help the decision makers in protecting the proposed road and to minimize the flood hazards.

Husain (2017) according to HEC-RAS is an integrated system of software, designed for interactive use in a multitasking, multi-user network environment. The system is comprised of a graphical user interface (GUI), separate hydraulic analysis components, data storage and management capabilities, graphics and reporting facilities. The HEC-RAS system will ultimately contain three 1-dimensional hydraulic analysis components for: (1) Steady flow water surface profile computations; (2) unsteady flow simulation; (3) Movable boundary sediment transport computations. Currently steady and unsteady flows are available and sediment transport is under development. A key element is that all three components will use a common geometric data representation and common geometric and hydraulic computation routines. In addition to the three hydraulic analysis components, the system contains several hydraulic design features that can be invoked once the basic water surface profiles are computed; including bridge scour computations, uniform flow computations, stable channel design, and sediment transport capacity.

Duressa*et al* (2018) guides the general objective of the study is to analyze Dam break by using hydraulic models (Hydraulic Engineering Center's River Analysis system). For this study the failure location is assumed to be at the center of the dam due to presence of high hydrostatic pressure and develop equally in both sides. From the result of Fincha'a dam break simulation the peak discharge formed by overtopping mode of failure is more devastating than the piping mode of failure. The effect of dam breach parameters on discharge is more pronounced than that of the water level. Dam break has greater impact on the downstream location where is closer to the dam in accordance with the hydrograph at downstream locations. The created Fincha'a river network was exported to HEC-RAS model for further dam break analysis by addition of different geometric data including dam information, calculated breach parameters, initial condition, upstream and downstream unsteady boundary condition. After full computation the model result were exported to integrated Arc-GIS and HEC- GeoRAS model for mapping flood inundation. Developed inundation map guides the dam owners and emergency management authority to give emergency action plan for the highly affected area by flooding and used for planning future economic development activities.

Roland*et al*(2018)This paper presents the methodology and results of water flow modeling focusing on the open channel of the Slatvinec stream running through the north-east Slovakian village of Kružlov. The underlying study involved: i) developing a flood model using Hydrologic Engineering Center's River Analysis System (HECRAS); ii) identifying areas of flood risk in the village using Geographic Information System (ArcGIS); iii) evaluating flood damage using Cost Analysis (CA). The model created in HEC-RAS software using the data collected enabled the water level in the stream profiles, flow rate and velocity, and finally the potential extent of flooding to be determined. The benefit of this research lies in the exact identification of the floodrisk areas along the course of the Slatvinec stream through the village of Kružlov, using a flood model of the area created on a Geographic Information System platform. Cost analysis is useful for evaluating flood damage to property, and the results of this hydrodynamic modelling may contribute to scientific research and to the practical application of flood mitigation and protection measures in other areas.

B. and Kumar (2018) dams are constructed across the river to create reservoirs and these reservoirs serve multipurpose objectives of water supply and disaster management. Because of siltation and high flood waves, catastrophic failure of dams may occur. In this study HEC-RAS model is used for dam break analysis of Kalyani dam constructed across Swarnamukhi River near Tirupati, Andhra Pradesh. In the present analysis, HEC-RAS was used to simulated unsteady flow in the Kalyani dam and results are mapped, in terms of water level in the river and floodplains. The height shape results as of the barrier breakdown model supply a general dimension of the overflow danger and provides nearby intended for emergency alert was prepared. The procedure intended for congregation along with prepare information, create an unsteady-flow module in HEC-RAS model. The area of water spread, depth of water along with probable maximum flood, travel time and plot to overflow succession was assess in this study. All these information predicted from the HEC-RAS model will helpful in defining the maximum height of flood protection structures in the area to protect it from flooding during high floods. The results of the study will be helpful for evacuation planning, estimation of damages and post flood recovery in the area.

Khalfallah*et al*(2018)the floods have become a scourge in recent years (Floods of, 2003, 2006, 2009, 2011, and 2012), increasingly frequent and devastating. Tunisia does not escape flooding problems, the flood management requires basically a better knowledge of the phenomenon (flood), and the use of predictive methods. In order to limit this risk, we became interested in hydrodynamics modeling of Medjerda basin. To reach this aim, rainfall distribution is studied and mapped using GIS tools. In addition, flood and return period estimation of rainfall are calculated using Hyfran. Also, Simulations of recent floods are calculated and mapped using HEC-RAS and HEC-GeoRAS for the most recent flood occurred in February March 2015 in Medjerda basin.

Oubennaceur*et al* (2018) this paper presents a probabilistic approach for flood risk assessment in a reach of the Richelieu River, south of Saint-Jean-Sur-Richelieu, Quebec, Canada. The approach is based on a combination of three simple modules: 1) flood frequency analysis (frequency and peak discharge), 2) estimation of inundation depth, and 3) damage and loss estimation. To assess the flood negative impacts, a simple hydraulic model is developed designed to replace and complement the existing 2D model coupled to an existing damage model. By simplifying the spatial coverage of flood calculations, this approach accelerates the computational efficiency enabling a broader set of elements to be combined in a large sample of Monte Carlo simulations applied in the flood risk assessment. The final result is a local scale risk map indicating the expected annual damage to each individual building in the study area useful for flood risk decision making. The analyses show that the approach is particularly powerful for flood risk assessments in areas adjacent to the river for which sufficient data is available.

The analysis of the results shows a good correlation between simulated parameters and those measured. There is a flood of the river exceeding 240m3/s (DGRE, 2015) and more flowing sections are observed in the future simulations; for return periods of 10yr, 20yr and 50yr.

CHAPTER – 3

MATERIALS & METHEDS

3.1. Study Area and Data Collection

3.1.1. Location

Gunta Nala Irrigation Project Dam is located at near Raipura village 26 km from head quarter of District Chitrakoot, Uttar Pradesh State. Gunta River is one of the tributary of Yamuna River. The project area is located between 25^0-13'-10" N Latitude and 81^0-9'-00" E Longitude and dam elevation between 107 to 133m (MSL). This dam is constructed for irrigation, fishery and drinking water purposes.

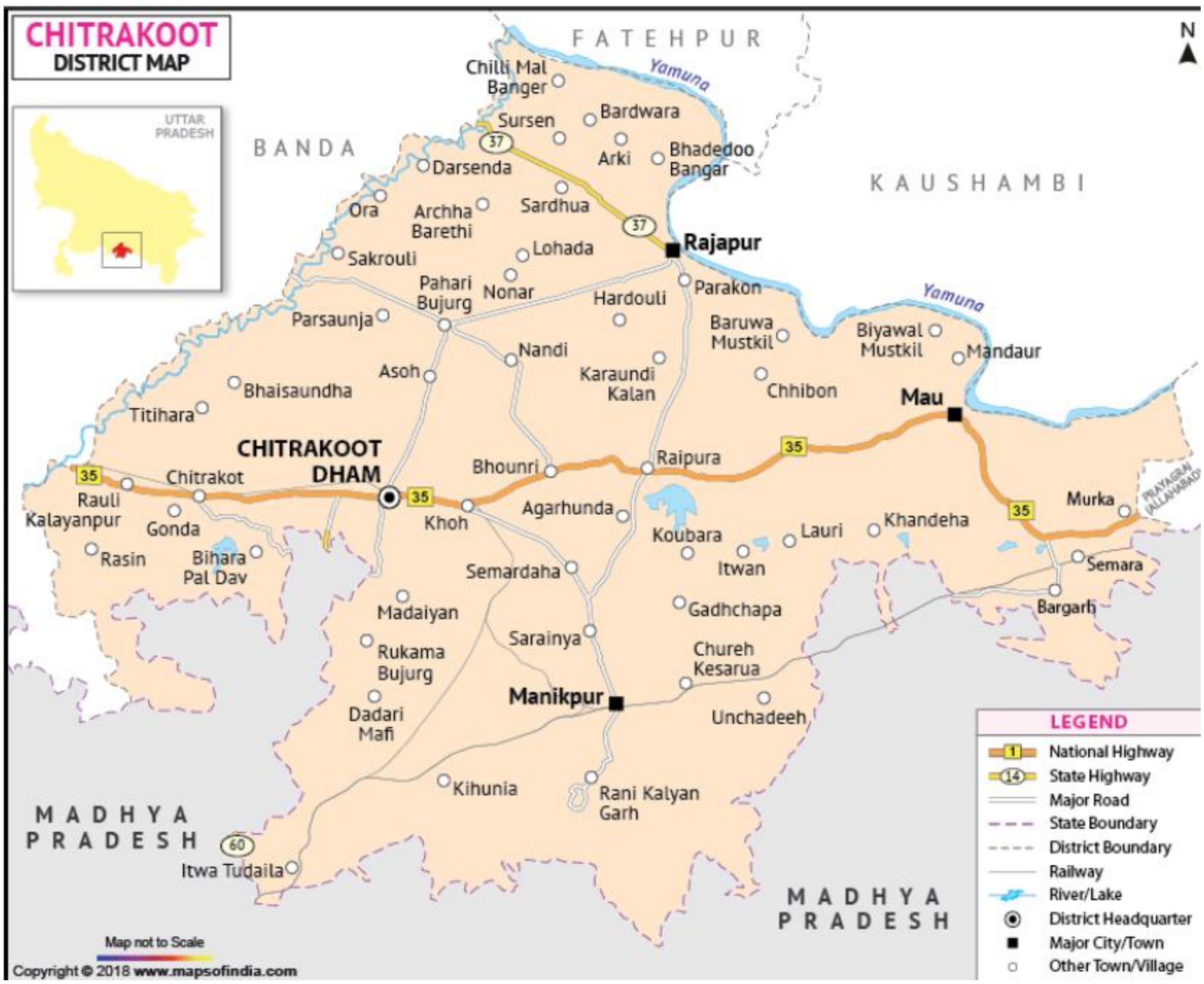


Figure: - 3.1 District map of Chitrakoot

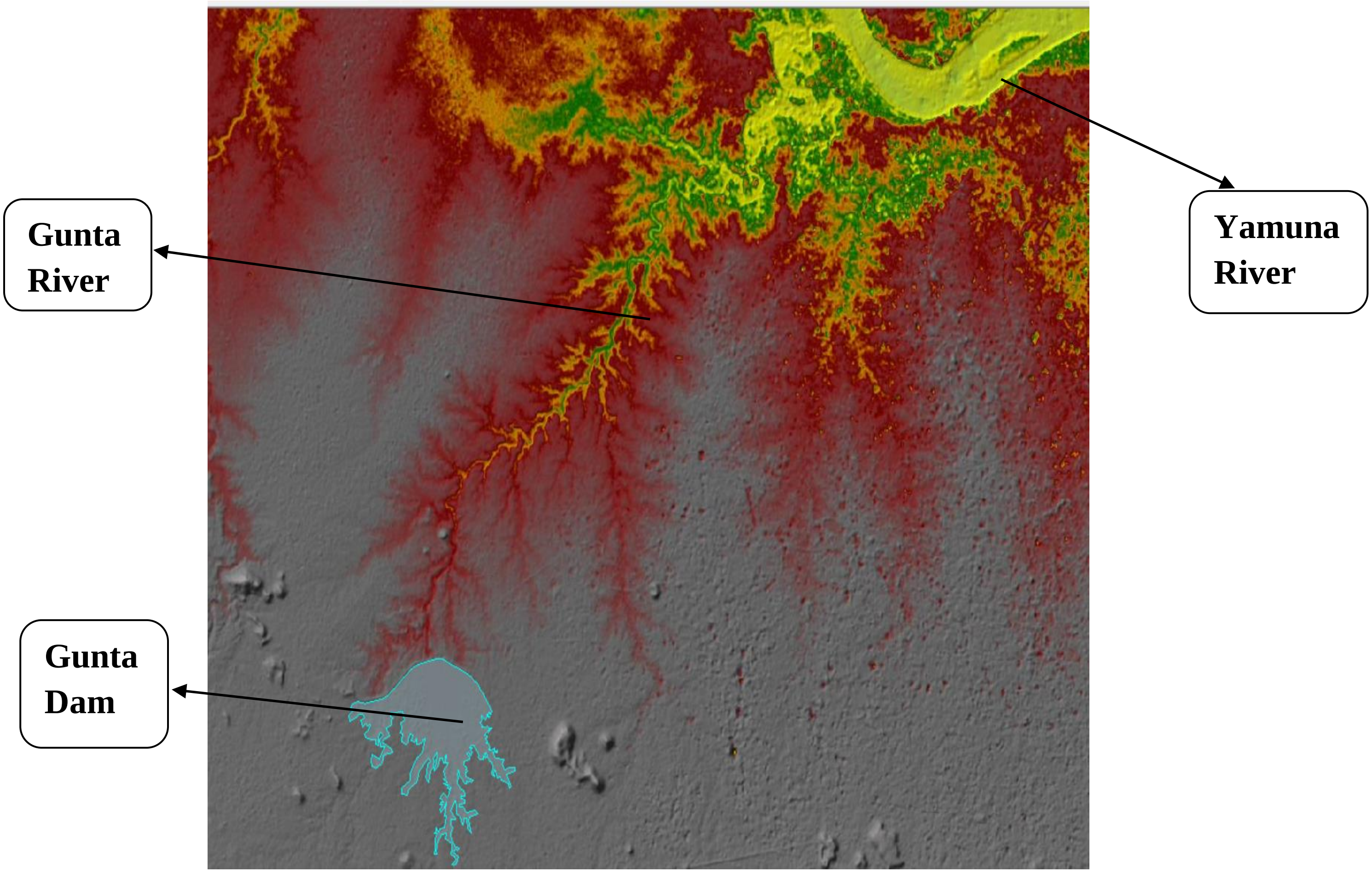


Figure: -3.2 Geographical Location of the Study Area (DEM)

3.1.2 Data collection

The required data are hydrological, Metrological data and Physical characteristic data of dam collected from Department of Irrigation Karwi, Chitrakoot, and Uttar Pradesh. The Digital Elevation Model (DEM) data is downloaded from online site (www.earthexplorer.usgs.gov) and cut by Arc GIS. Digital elevation model (DEM) is being used for determining elevations at any point, slope and aspect and for finding features on the terrain, such as drainage basins and watershed, drainage networks and channels, peaks and pits and other landforms.

3.1.2.1 Climatic Data

The climate of Gunta Nala watershed is subtropical monsoon with an average annual rainfall of 980.1 mm. Most of the rain falls during the month of June to September. Maximum temperature of District is 45-48 ^{0}C during May & June and minimum temperature is 3.0-8.6 &^{0}Cduring December & January (Source: District Survey report Chitrakoot, 2018). During

March to May the air is least humid with relative humidity high in the morning and less in the evening mean monthly morning RH is 85% and mean monthly evening RH is 57%. During monsoon season the winds blow predominantly from east or southeast (Source: Meteorological Department Govt. of India, 2010).

3.1.2.2 Dam Data

The crest length of the Gunta Nala dam is 5700 m with a maximum height, top width and crest elevation 25.4m, 6m and 125.50 m (m.s.l) respectively. The bed level of reservoir is 100.1 m from mean sea level. Its Reservoir area at 122m (m.s.l) is 8.1 km^2.

Table - 3.1 General Data of Gunta Nala Dam

GENERAL DATA	
Dam Type	Earth Filled
Dam Crest Level	125.5 m
Dam Crest Width	6 m
Dam Crest Length	5700 m
Spillway Type	Ogge Type
Maximum Reservoir Water Level	25.4 m
Maximum Reservoir Capacity	28.80 x 10^6 m^3
Maximum Reservoir Area	8.1 km^2 122m (m.s.l.)
Maximum Reservoir Operation Level	115.1 m
Maximum Reservoir Operation Area	3.8 km^2
Probable Maximum Flood	648.7 cumecs
Total River Length of Down Stream	25.97 km
Irrigable Command Area (CCA)	11600 ha
Annual Irrigation	3880 ha
Average Annual Precipitation	980.1 mm

3.1.2.3 Land Use Pattern

The stored water behind Gunta Nala Dam will be diverted into canal system on the right from river. The water is providing through a network of canal system for irrigation for command area of 11600 hectare irrigable land. This irrigable command area is located at a distance of about 0 to 37.1 km downstream from Gunta Nala Dam. The left bank command area covers an irrigable area of 3755 hectare whereas the right bank command area covers 125 hectare (Source: Irrigation Department Chitrakoot)

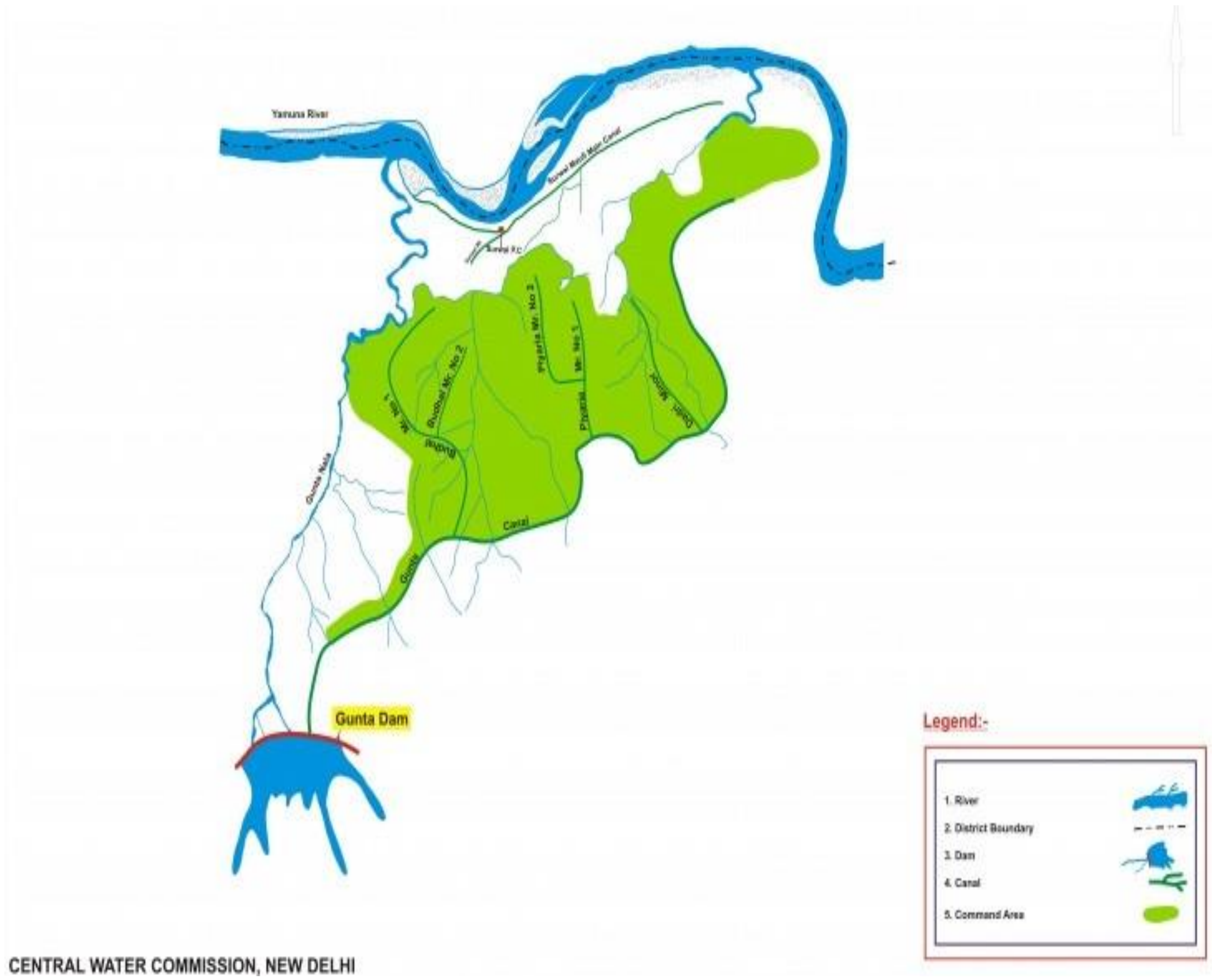


Figure: -3.3 Down Stream with Dam

3.2 Digital Elevation Model (www.earthexplorer.usgs.gov)

Dam breach analysis involves routing the outflow hydrograph from the breached dam throughout downstream of the river from the dam up to the downstream boundary, this will require elevation data of the reservoir and elevation data of the cross section of the river including the flood plain. Digital Elevation Model (DEM) is used as a source of elevation data for this study.

Digital Elevation Model (DEM) consists of a sampled array of elevation for a number of ground positions at regular spaced intervals (USGS). Digital Elevation Model have various spatial resolutions, in this study 30m grid size of DEM is used. Digital Elevation model for the study area is shown in figure-3.4.

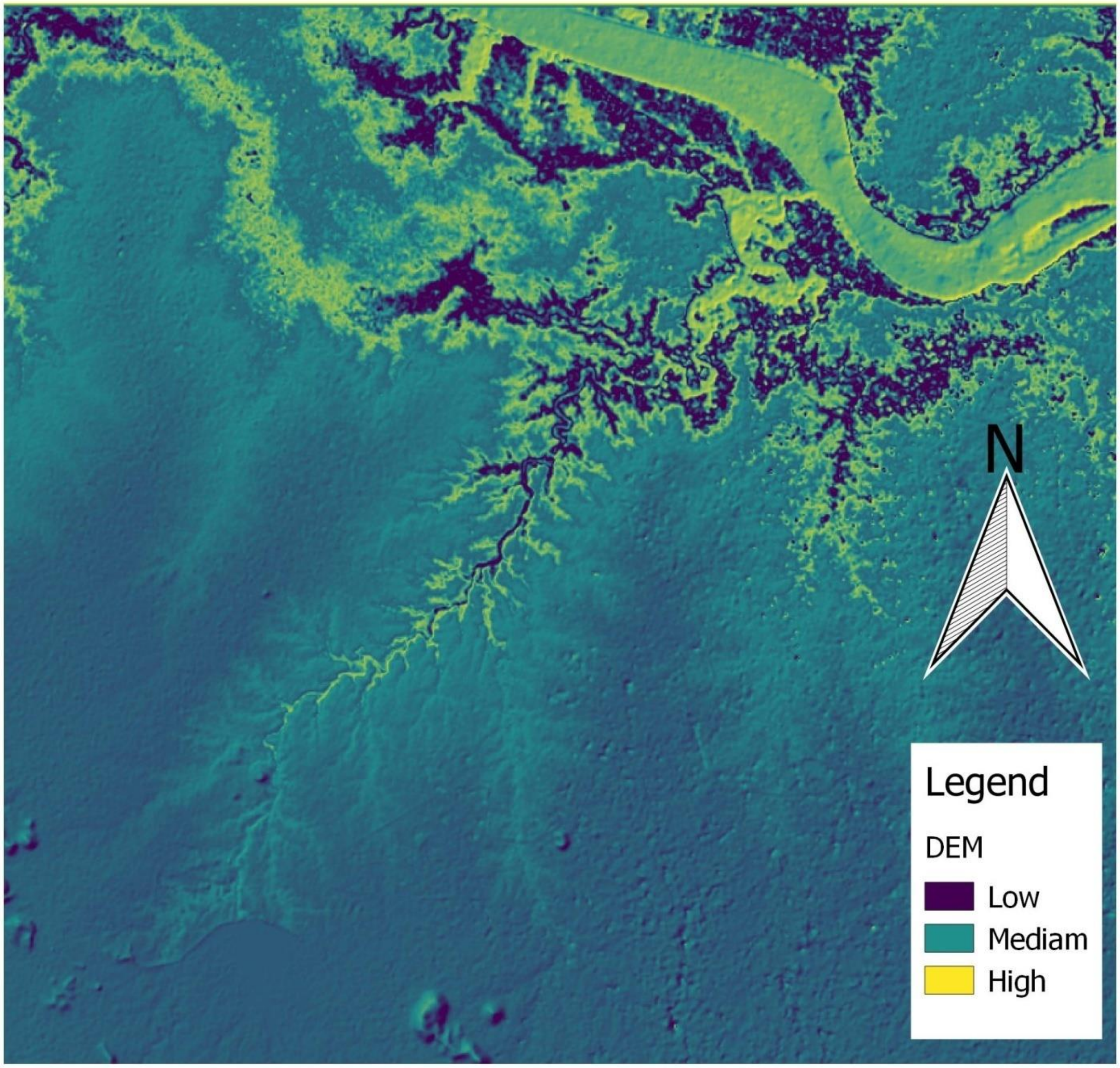


Figure: - 3.4 Digital Elevation Model of the Study Area

3.3 Dam breach parameter

The estimation of possible breach dimensions and development time is necessary in any assessment of dam safety since breach parameters will directly and substantially affect the estimate of the flow, inundated areas and warning time at the downstream locations (Gee, 2009).

The available breach parameter and peak breach flow estimation techniques can be classified into three categories, as follows: Comparative analysis, Regression-based methods based on data collected from actual dam failures and Physically-based simulation models (Chauhan, 2005).

In this study the MacDonald and Langridge-Monopolis (1984) and Froehlich (2008) which are empirical formulas developed from regression analysis of data collected from various dam failures, Froehlich (2008) is used to estimate the Dam breach parameters of Gunta Nala Dam as the formulas has been used and tested more than 74 dams.

Summary of MacDonald and Langridge-Monopolis (1984) and Froehlich (2008) empirical equations are shown in table:-3.2

Table: 3.2 MacDonald and Langridge-Monopolis (1984) and Froehlich (2008) empirical equations

Breach Parameters	**MacDonald and Langridge_Monopolis (1984)**	**Froehlich (2008)**
Volume Eroded V_{er} (m^3)	$V_{er}=0.0261(V_{out}\times h_w)^{0.769}$ (earth fill)	
	$V_{er}=0.00348(V_{out}\times h_w)^{0.852}$ (rock fill)	
Breach Width B (m)	$B_b=\dfrac{V_{er}-h_b^2(CZ_b+h_bZ_bZ_a/3)}{h_b(C+h_bZ_s/2)}$	$B_{avg}= 0.27\ K_0\ Vw^{0.32}\ H_b^{0.04}$ K_0=1.0 for piping K_0 =1.3 for overtopping
Breach Side Slope (H:V)	0.5:1	0.7:0.7 piping 1.0:1 overtopping

Breach Development Time T_f	$T_f = 0.0179 V_{er}^{0.364}$ (hr)	$T_f = 63.2 \sqrt{V_W / g H_b^2}$ (sec)

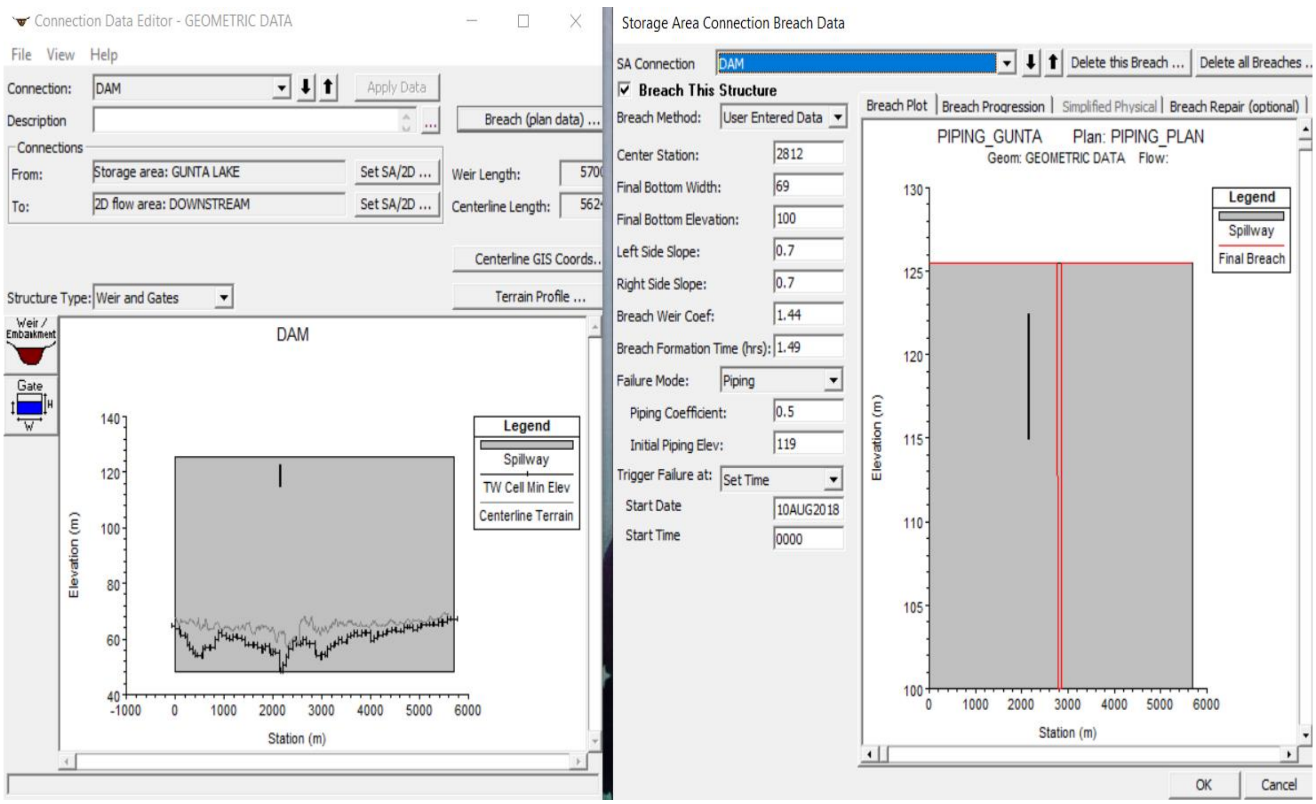


Figure:- 3.5 Breach parameter for piping (HEC-RAS 5.0.3)

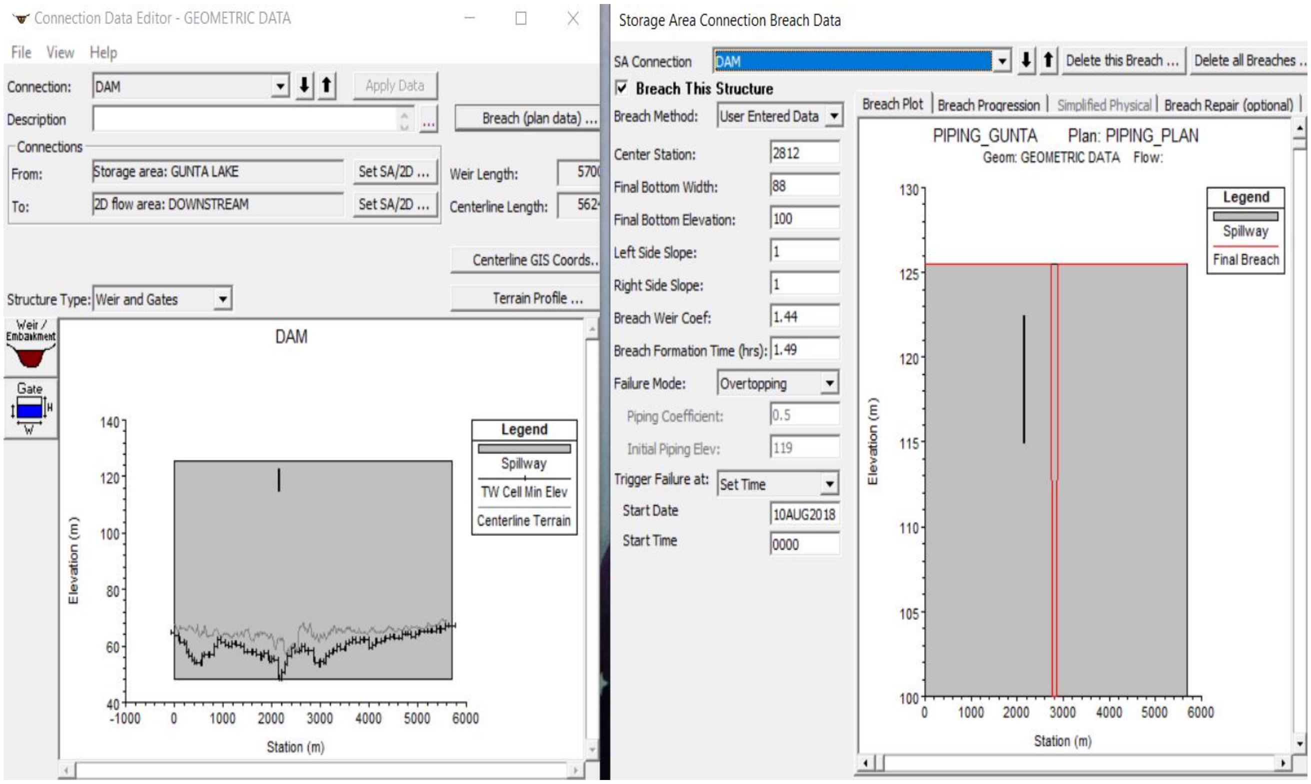


Figure:- 3.6 Breach parameter for overtopping (HEC-RAS- 5.0.3)

3.4 Hydraulic model development

Hydraulic model of Natural River could be successfully analyzed with four equations: continuity, energy, momentum, and manning. The manning equation is considered to be empirical and is used to estimate friction loss while the energy equation is considered semi-empirical (Saleh, 2009).

One-dimensional (1D) flow routing approaches such as HEC-RAS and some which are based on the saint venant equations or variations. The widespread usage in practice might be explained not only by the fact that 1D models are (in comparison to higher dimension hydraulic models) simpler to use and require a minimal amount of input data and computer power, but also because the basic concept and programs have already been around for several decades (US Army Corps of Engineering 5.0.3).

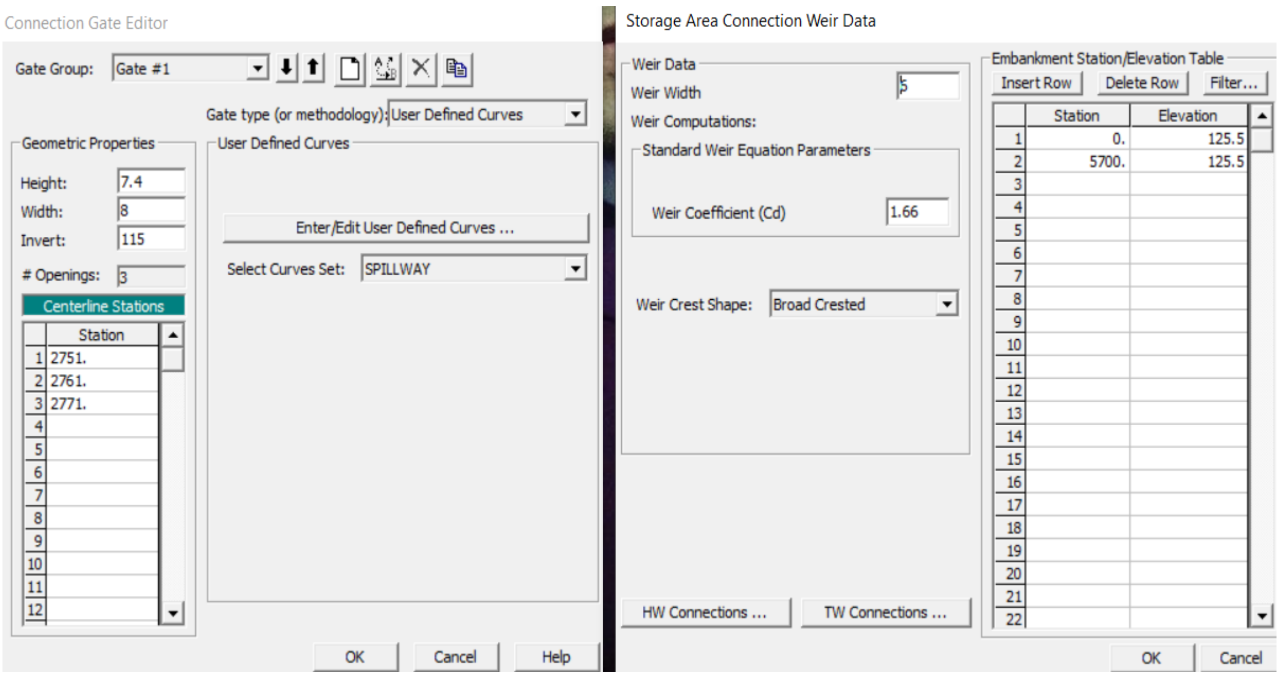
In this study, the hydraulic model used is HEC-RAS which is a public domain model developed by the US Army Crop of Engineers (USACE, 5.0.3). It performs one dimensional steady and unsteady flow calculations on a network of natural or manmade open channel.

3.4.1 HEC-RAS Modeling

HEC-RAS is a one-dimensional river hydraulics model used for steady- flow and unsteady-flow water surface profile computations though a network of open channels (HEC, 5.0.3). Because HEC-RAS solves the full Saint-Venant equations, it is well suited for computing the flood wave propagation resulting from a dam failure scenario (Cameron T., 2008).

3.4.2 Dam Profile

A dam is modeled in HEC-RAS as an inline structure. An inline structure is represented with a weir profile (that includes the spillway and gates). An inline structure can be directly added to HEC-RAS. In this study the inline structure is added to HEC-RAS 5.0.3. This data include a weir/Embankment profile, and any gated spillways. In this study weir and Gates are entered. Figure-3.7 shows profile of Gunta Nala dam as an inline structure in HEC-RAC 5.0.3.



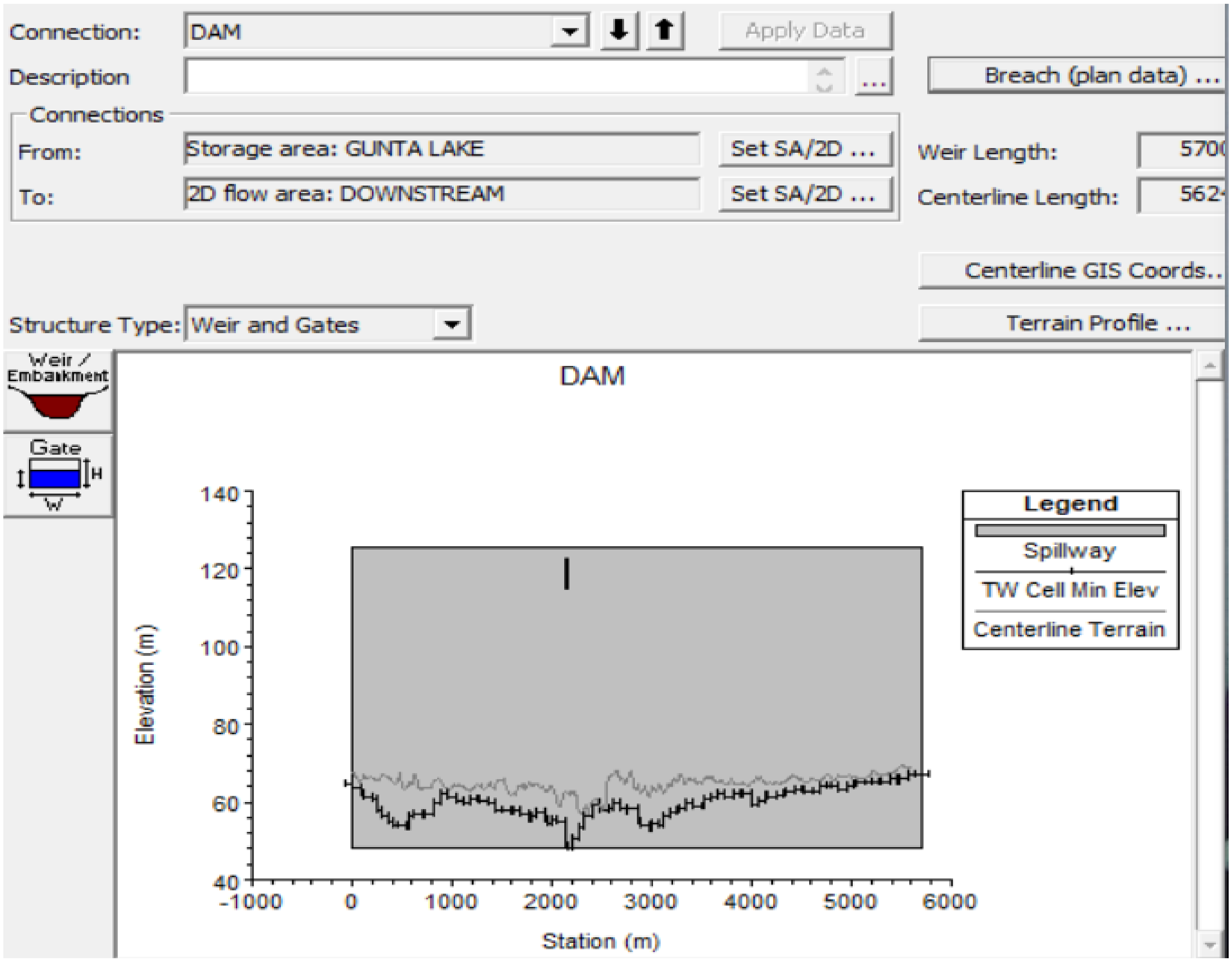


Figure:- 3.7 Dam breach data of Gunta Nala dam (HEC-RAS 5.0.3)

3.4.3 River Cross Section

River cross sections are one of the key inputs to HEC-RAS. Cross sections are digitized in HEC-RAS using the RAS MAPPER tool and are imported into HEC-RAS along with other geometric data. Cross section cutlines are used to extract elevation data from the terrain to create a ground profile across channel flow (Merwade, 2012). In this study cross section cut lines are digitized every 472.2 m along downstream of the river from the dam up to the downstream boundary 25.97 km. Figure-3.8 show cross section cutline across Gunta River and other geometric data in HEC-RAS 5.0.3

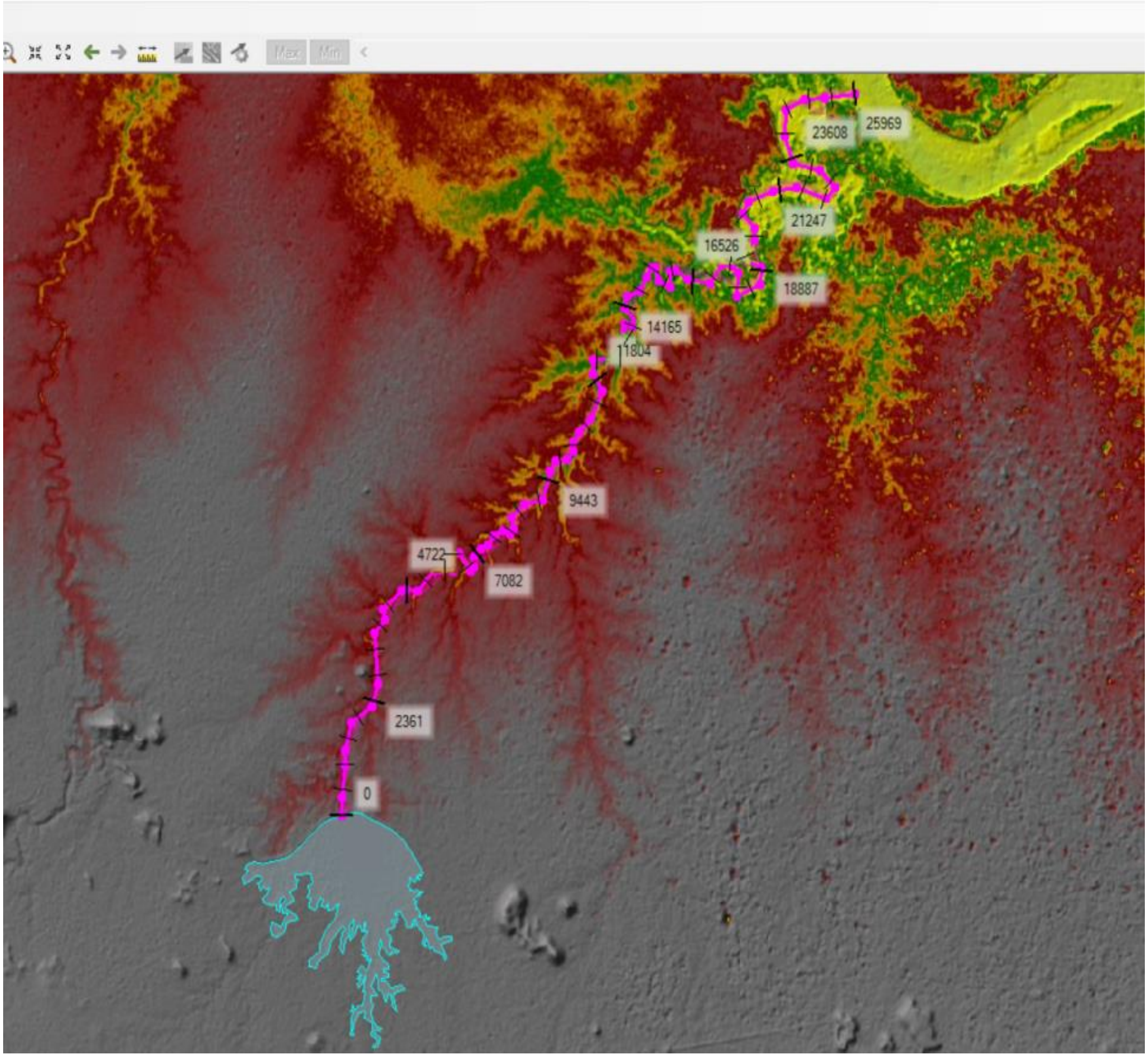


Figure:- 3.8 River Cross Section of Gunta River (RAS-MAPPER)

3.5 Simulation of Unsteady flow analysis

Flood is a typical example of unsteady flow since the stage of the flow changes instantaneously as the flood wave pass by (Chow, 1960). In this study HEC-RAS is used to simulate unsteady flow throughout the downstream of Gunta River from Gunta Nala dam up to the downstream boundary 25.97 km from the dam. Once all of the geometric data are entered in to HEC-RAS, required unsteady flow data must be entered to undertake the unsteady flood simulation. Unsteady flow data includes boundary conditions at all of the external boundaries of the system, as well as any desired internal locations, and set the initial flow and storage area condition at the beginning of the simulation. Generally unsteady flow data required are boundary condition and initial condition.

There are different types of boundary conditions some of them are PMF inflow Hydrograph, Precipitation Hydrograph, Flow hydrograph, Rating Curve, Normal Depth, Lateral Inflow hydrograph etc. Unsteady flow data used as a boundary condition in this study are Precipitation Hydrograph and Normal depth. Normal depth can only be used as a downstream boundary condition for an open ended reach. To use normal depth it is required to enter a friction slope for the reach in the vicinity of the boundary condition. The slope of the water surface is often a good estimate of the friction slope (HEC-RAS). In addition to the boundary condition, initial condition should be established at the beginning of the unsteady flow simulation. Initial condition consists of flow and stage information at each of the cross sections, as well as elevations for any storage areas defined in the system (HEC-RAS).Once all the geometric and unsteady flow data have been entered, unsteady flow calculations can be performed. Unsteady flow analysis window helps in unsteady flow analysis which is computed by HEC-RAS. Figure 3.9& 3.10.

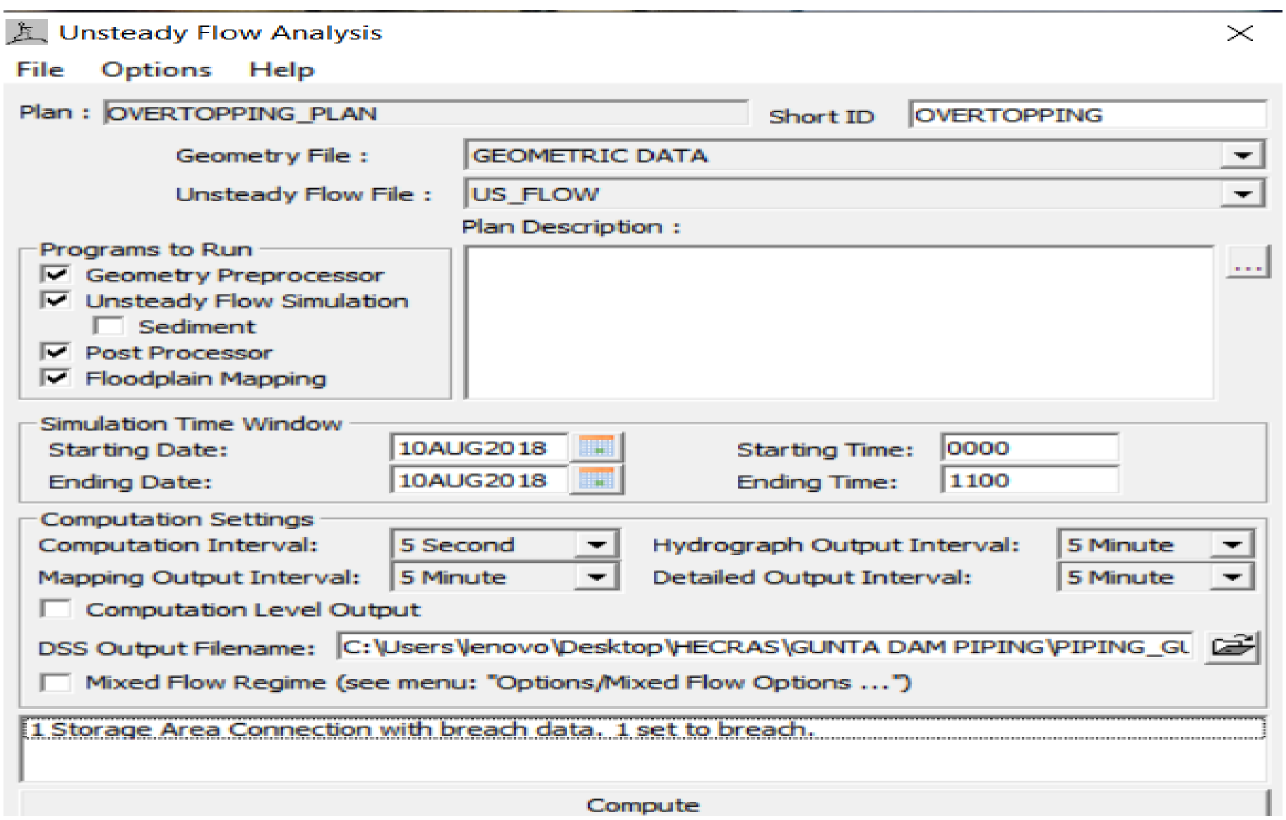


Figure:- 3.9 Unsteady flow analysis window for overtopping (HEC-RAS5.0.3)

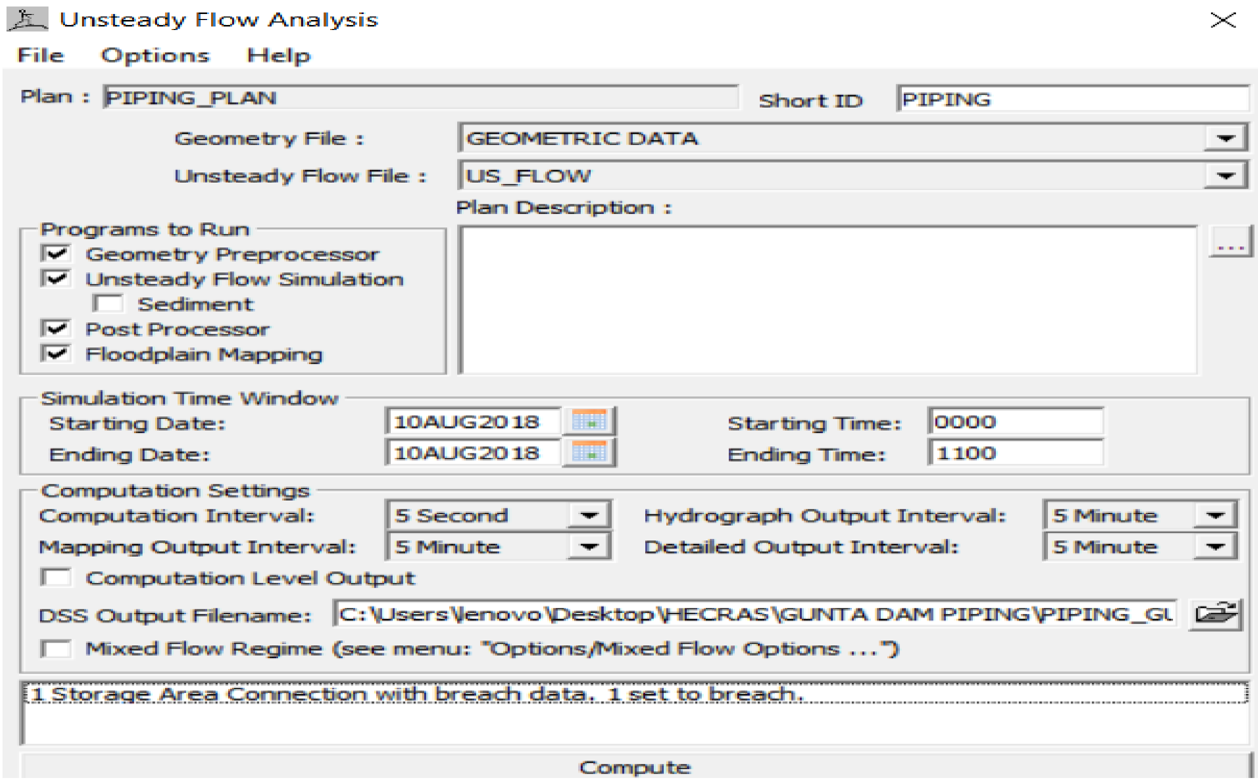


Figure:- 3-10 Unsteady flow analysis window for piping (HEC-RAS 5.0.3)

3.6 Flood Plain Mapping

After unsteady flow analysis in HEC-RAS where water surface elevations at locations from upstream boundary to downstream boundary are obtained, the next step is to use these water surface elevations for flood mapping. Floodplain mapping is accomplished by using QGIS.

To prepare the map in QGIS, GIS information is exported from HEC-RAS. The geo-referenced cross sections are imported and water surface elevations attached to the cross sections are used to create a continuous water surface. The water surface is then compared with the terrain model and the floodplain is identified where the water surface is higher than the terrain. QGIS produces inundation maps for flood extent and depth.

CHAPTER-4

RESULTS AND DISCUSSION

Based on the methodology and input requirement of the model selected, all the necessary steps are undertaken and the Dam Breach Analysis is simulated. So in this part all the necessary results will be shown and discussed towards the objective of the research.

4.1. Dam Breach Parameters Results

Estimating the dam breach parameters is one of the most important things that have to be done before dam breach analysis is simulated. Froehlich (2008) is used to estimate breach parameters. The modes of failure for this dam are assumed to be overtopping and piping type of failure.

Breach parameters are estimated for both overtopping and piping and are used as an input for HEC-RAS. This dam breach parameters breach width, breach side slope and breach formation time are used as a geometric data during unsteady flow analysis. Results of dam breach parameter calculations for overtopping and piping failure mode values Froehlich (2008) method is as follows.

4.1.1 Overtopping: - Froehlich (2008):

For overtopping case the failure location is assumed to be at main channel centerline (at half of the crest length of dam 5700 meters). From the calculation of breach parameters using Froehlich (2008)methods used in this study, the following results are obtained.

Average breach width

$$B_{avg}= 0.27\ K_0\ V_w^{0.32}\ H_b^{0.04}$$

$$B_{avg}= 88\ m$$

Breach formation time

$$T f=63.2\ \sqrt{Vw/gHb2}$$

$$T f = 1.49\ hrs$$

4.1.2 Piping: - Froehlich (2008):

Using Froehlich (2008) for piping case the failure, these values are

Average breach width

$$B_{avg} = 0.27\ K_0\ V_w^{0.32}\ H_b^{0.04}$$

$$B_{avg} = 69\ m$$

Breach formation time

$$T_f = 63.2\ \sqrt{V_w / g H_b^2}$$

$$T_f = 1.49\ hrs$$

Table: - 4.1 summary of estimated breach parameters

OVERTOPPING	
Breach bottom width	88 m
Breach side slope	1:1
Breach formation time	1.49 hrs
PIPING	
Breach bottom width	69 m
Breach side slope	0.7:0.7
Breach formation time	1.49 hrs

Based on the results from unsteady flow analysis, envelop curve and peak outflow regression equations, breach parameters from one of the method are selected.

4.2 Unsteady flow analysis

Unsteady flow analysis is the basic part of dam breach analysis where flood from the dam to the downstream boundary is routed. With all the necessary data HEC-RAS can perform unsteady flowanalysis. After entering boundary conditions for the farthest upstream and downstream cross sections and initial conditions in to HEC-RAS unsteady flow simulation can be initiated

In unsteady flow analysis of this study PMF inflow hydrograph of Gunta River and normal depth of the farthest downstream vicinity are used as a boundary condition and initial flow and elevation for the storage area are used as an initial condition.

4.2.1. WSE for Unsteady flow analysis of overtopping

Unsteady flow simulation of overtopping failure in HEC-RAS requires PMF inflow hydrograph as an upstream boundary condition. Overtopping failure occurs when the flood due to the PMF inflow passes over the embankment.

Flood resulting from the PMF of Gunta River is done during unsteady flow simulation. The PMF raises the reservoir water surface elevation to 125.5 m which is the dam crest. Figure 4.1

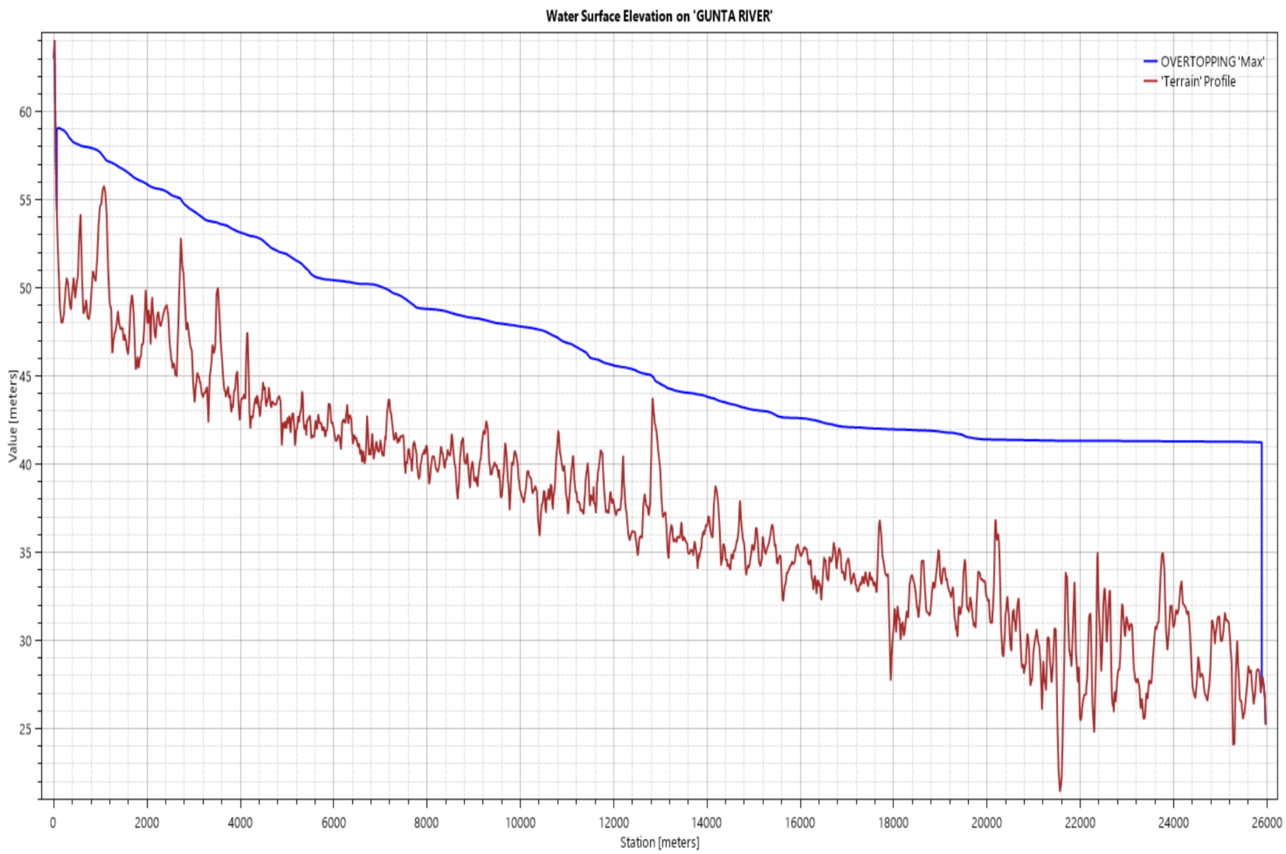


Figure:- 4.1 Water Surface Elevation of Overtopping (RAS Mapper)

4.2.2. WSE for Unsteady flow analysis of piping

Unsteady flow analysis due to piping of Gunta Nala dam in HEC-RAS is done after entering the necessary data for the simulation to begin. Dam breach parameters and boundary conditions are the necessary data that are inputted in HEC-RAS. Empirical formulas Froehlich (2008) is used to estimate breach parameters. Unsteady flow analysis of piping in HEC-RAS is done.

The starting water surface elevation for piping is taken at the crest of the spillway, since the spillway is only used during flood events. Figure 4.2 shows water surface elevation.

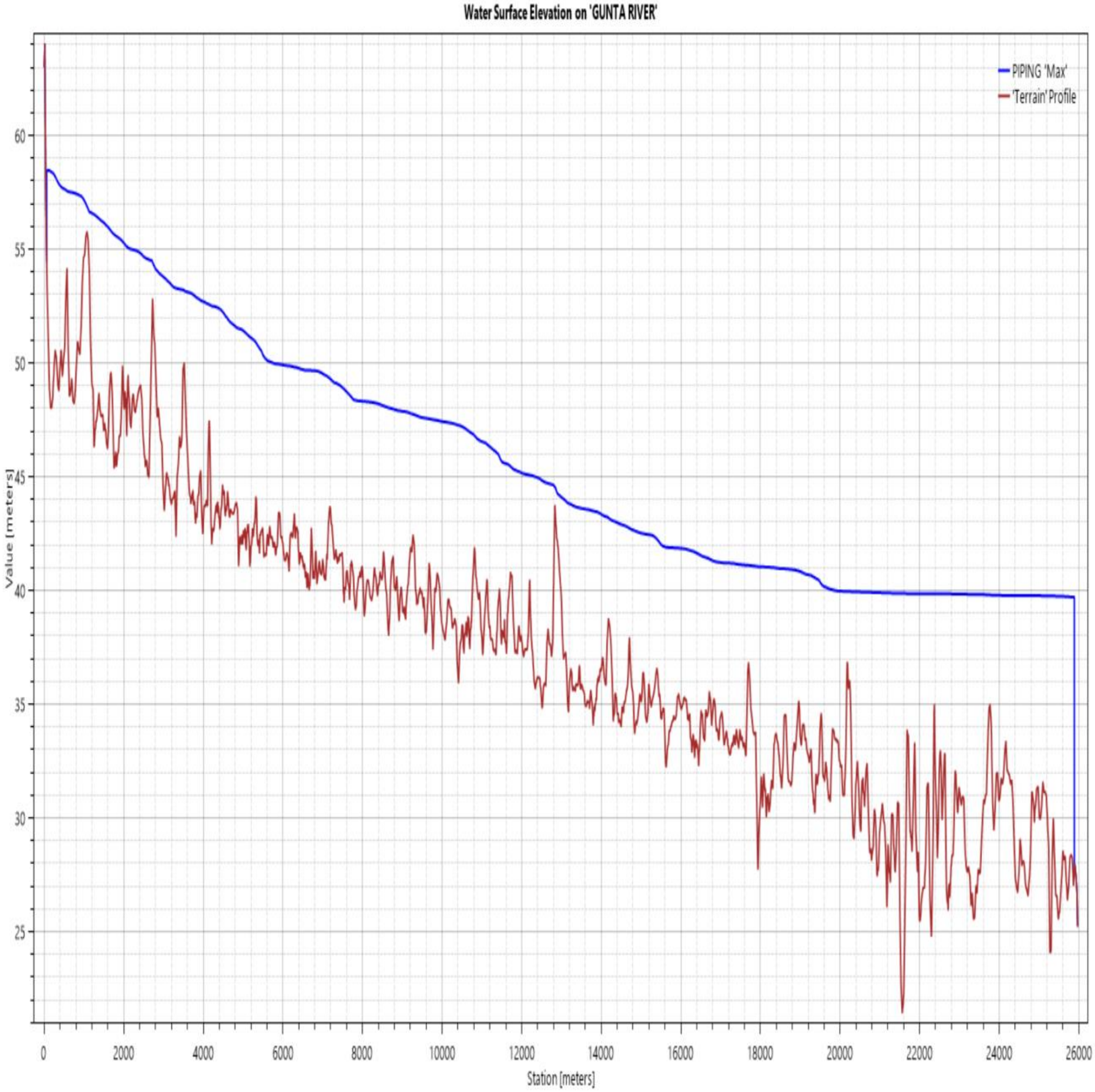


Figure: - 4.2 Water Surface Elevation of Piping (RAS Mapper)

Using breach parameters from Froehlich (2008) for unsteady flow analysis in HEC-RAS out flow hydrograph from the breached dam and hydrograph at every cross section are obtained after the unsteady flow simulation. In figure:- 4.3shows out flow hydrographs.

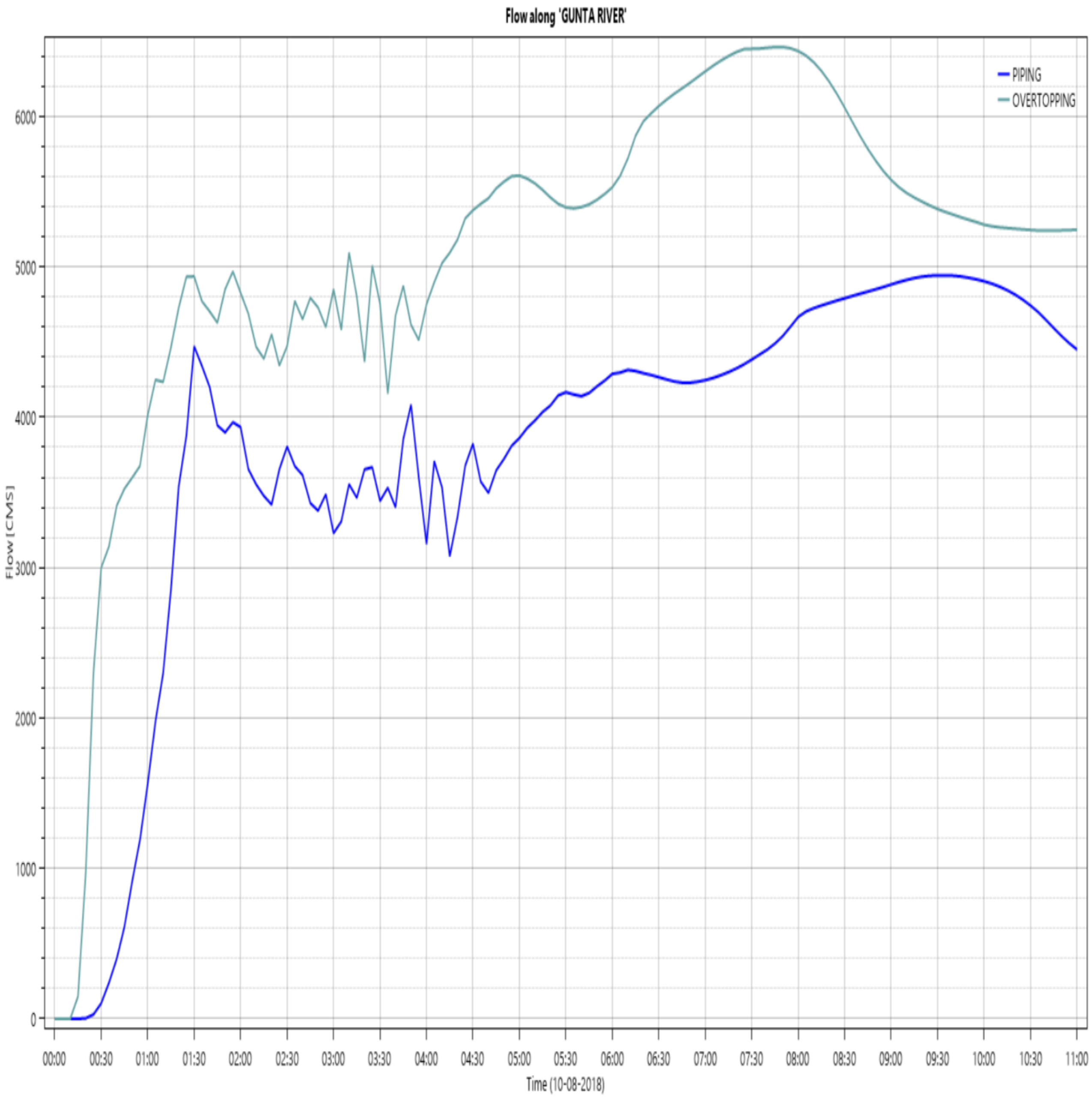


Figure:- 4.3 Out flow Hydrographs after unsteady flow analysis using Froehlich (2008) (RASMAPPER)

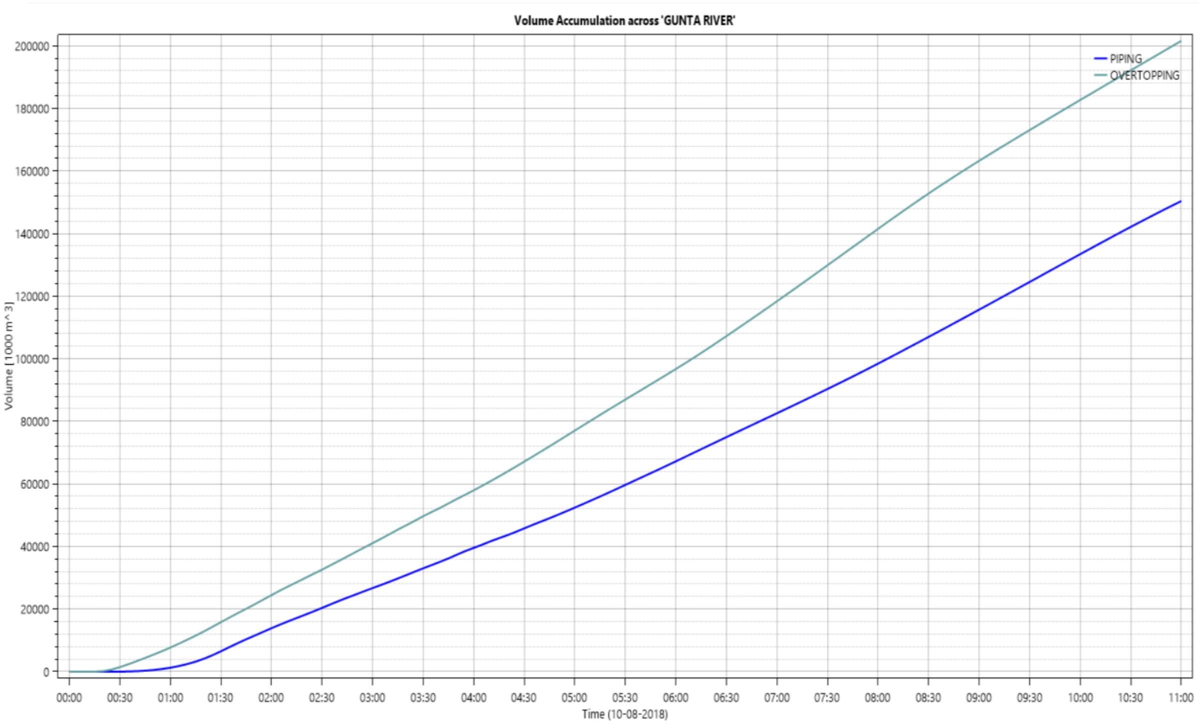


Figure:- 4.4 Volume Accumulation Along Gunta River (RAS MAPPER)

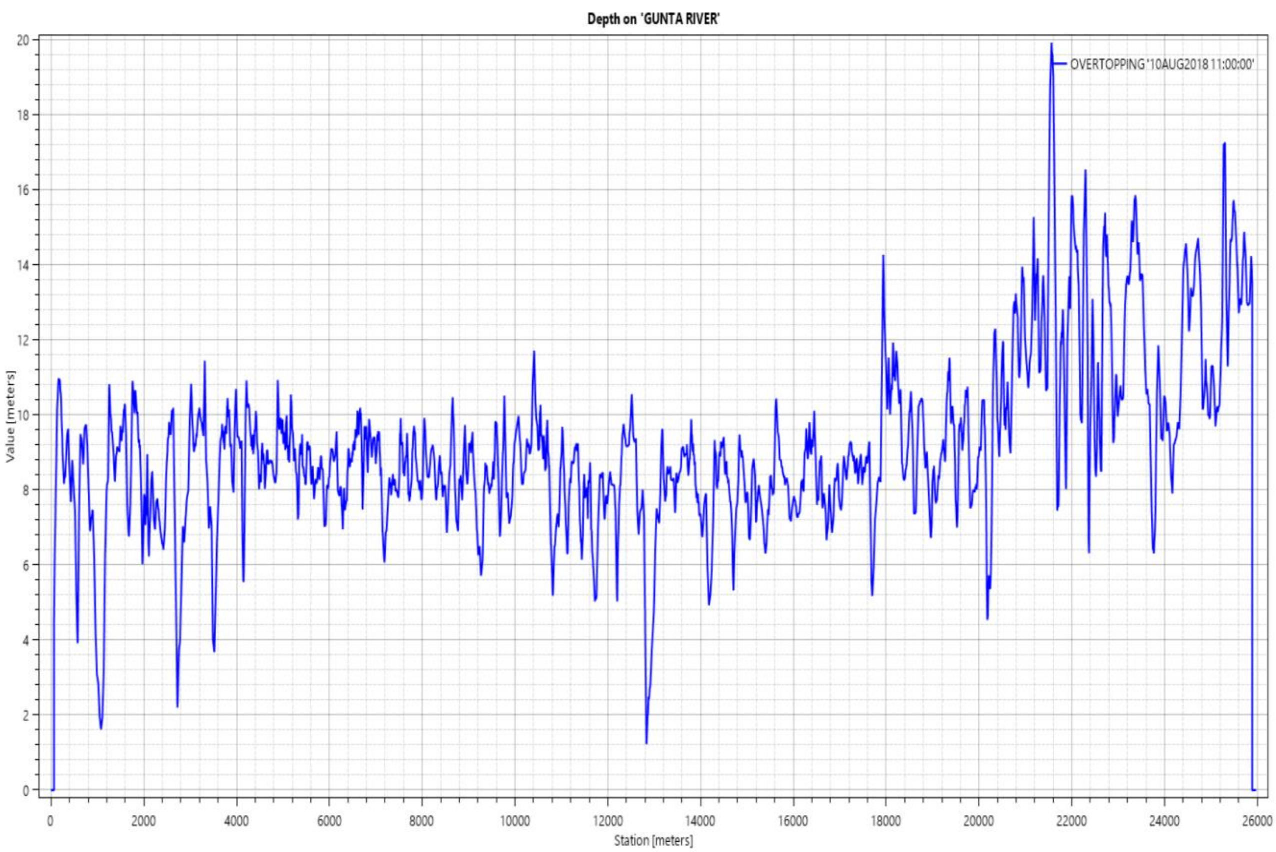


Figure:- 4.5 Depth Profile on Gunta River (RAS MAPPER)

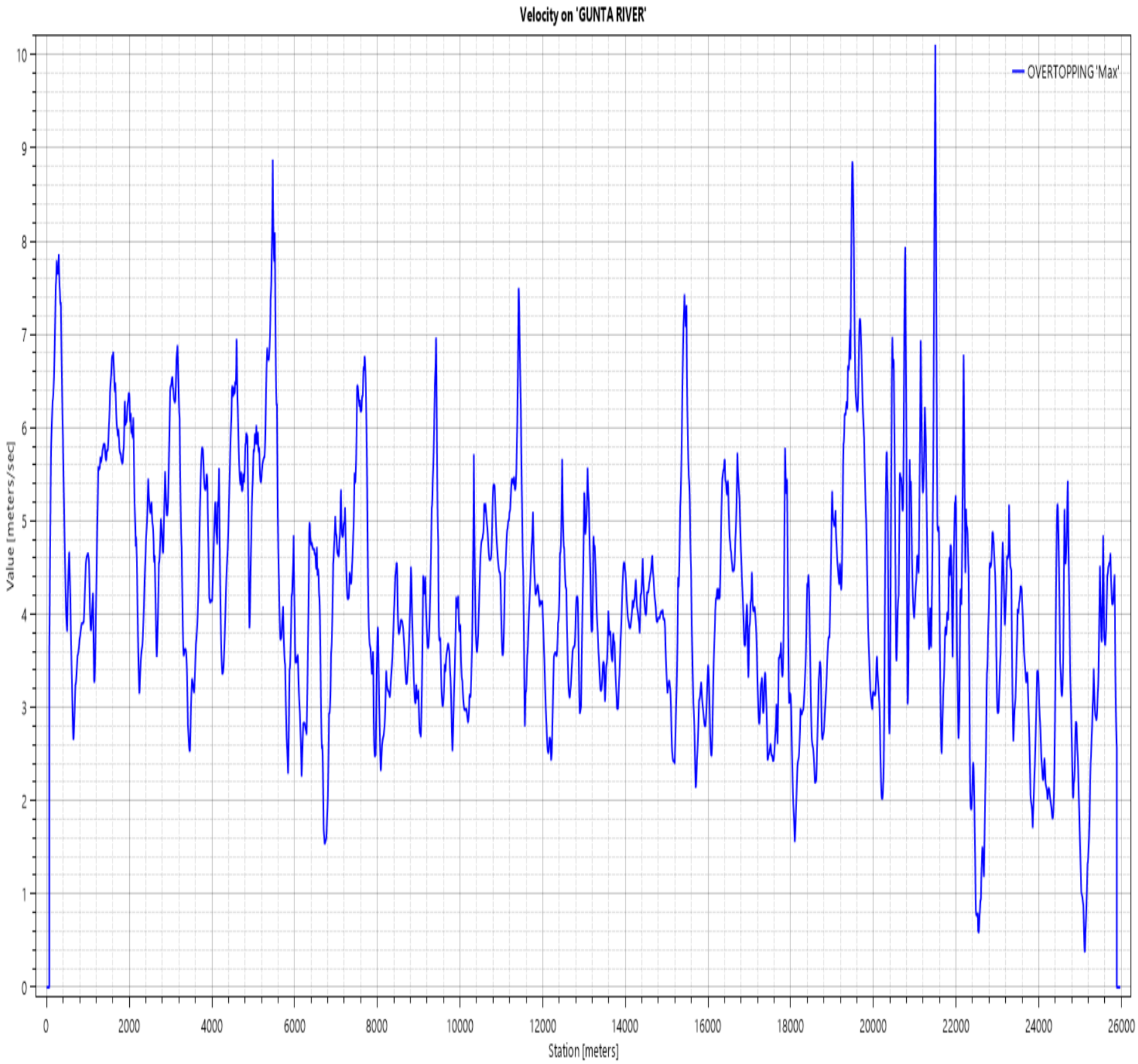


Figure:- 4.6 Velocity Profile on Gunta River (RAS MAPPER)

4.3 Flood mapping of piping and overtopping

Flood mapping is the final step in dam breach analysis. In this study performs the flood mapping process in RAS Mapper for piping and overtopping. The flood map shows the maximum water surface and up to where this maximum water surface extends on the flood plain. The flood map is created on a type of DEM called TIN which is derived from a raster. Once the flood map is created it can be shown on the TIN itself or on an aerial map of the study area. In figures shows map of the flood due to piping and overtopping of Gunta Nala Dam.

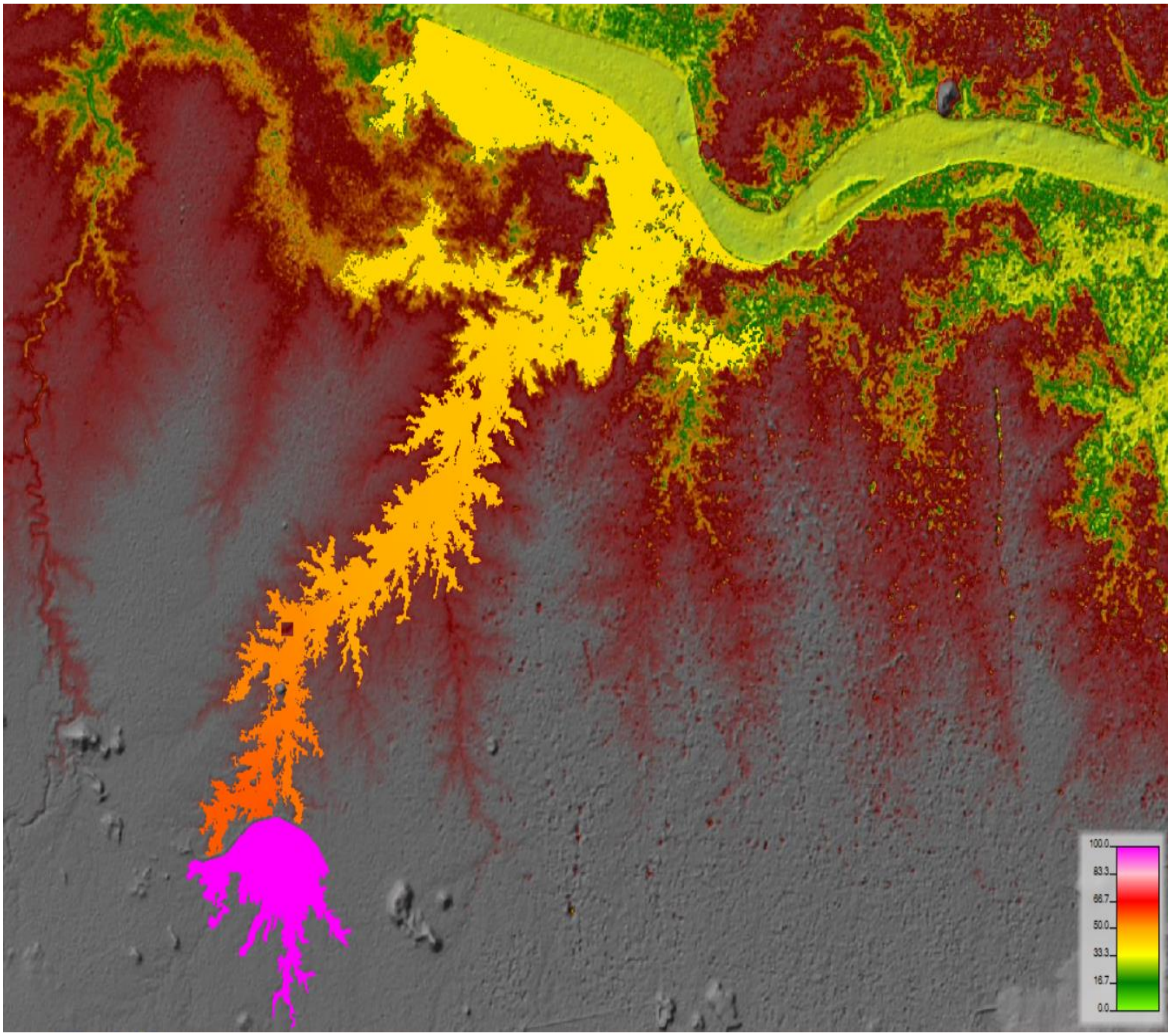


Figure:- 4.7 WSE for Piping On Gunta River (Ras Mapper)

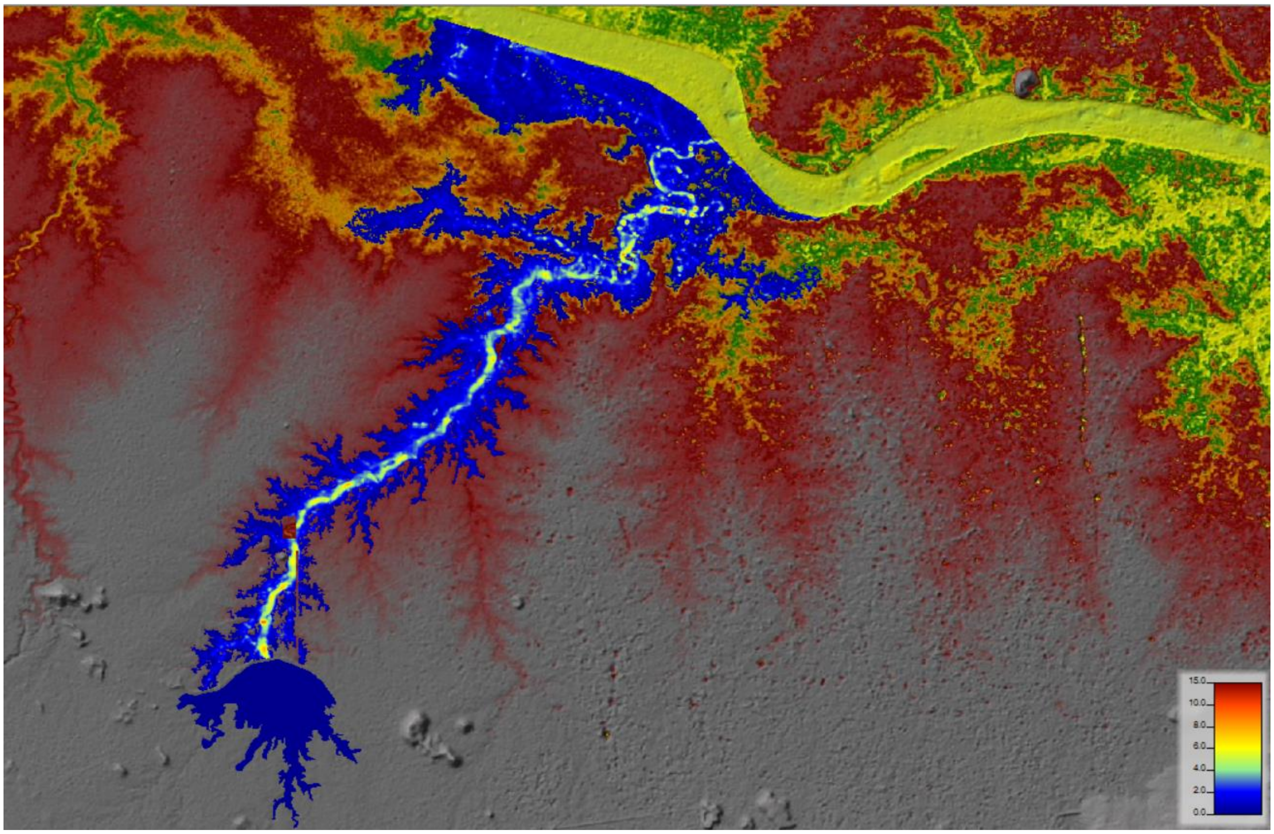


Figure:- 4.8 Velocity for Piping On Gunta River (Ras Mapper)

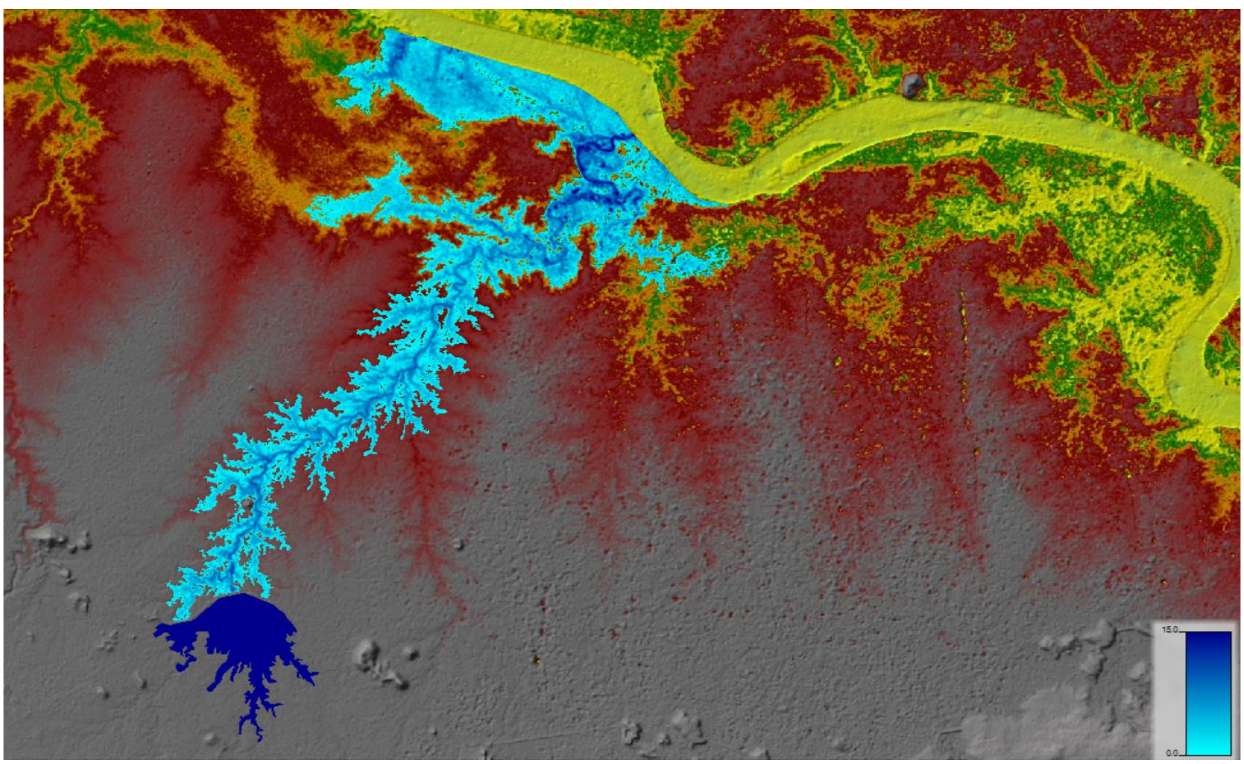


Figure:- 4.9 Depth for Piping On Gunta River (Ras Mapper)

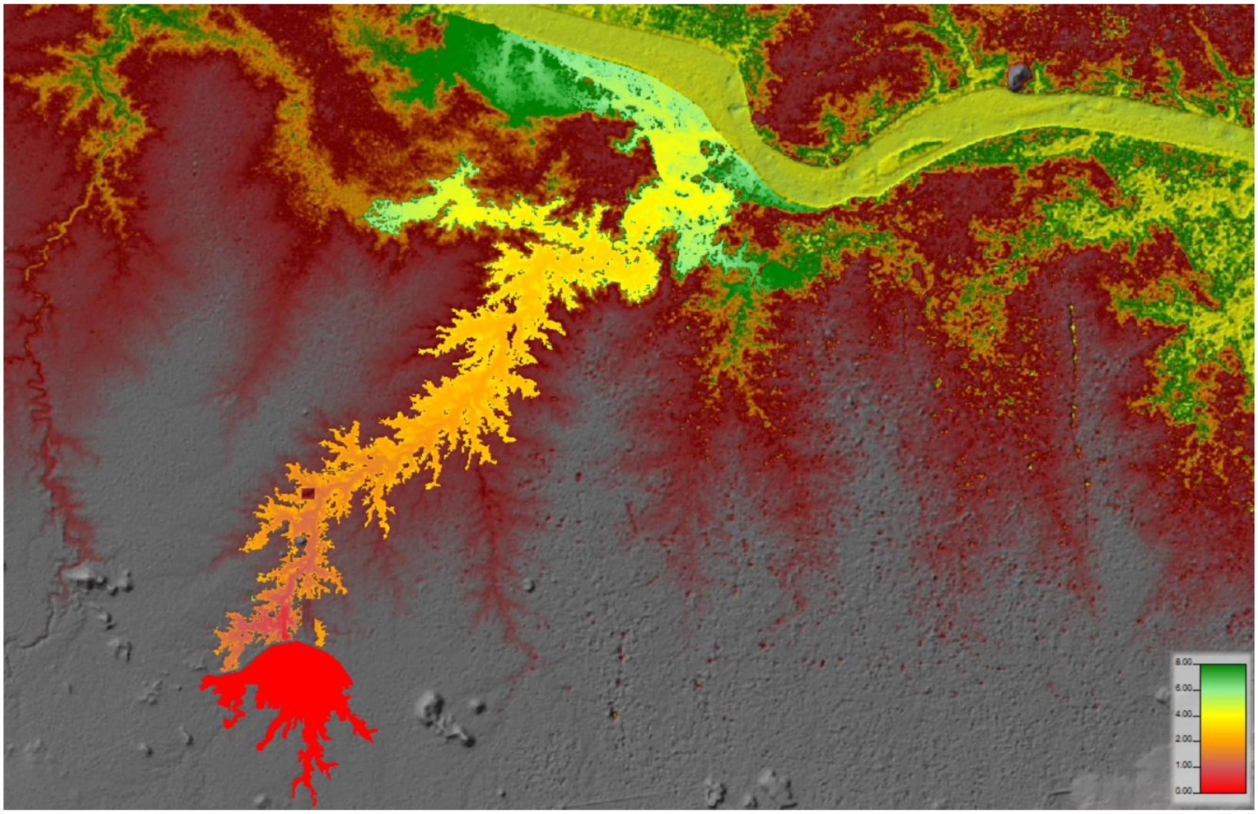


Figure:- 4.10 Arrival Time for Piping On Gunta River (Ras Mapper)

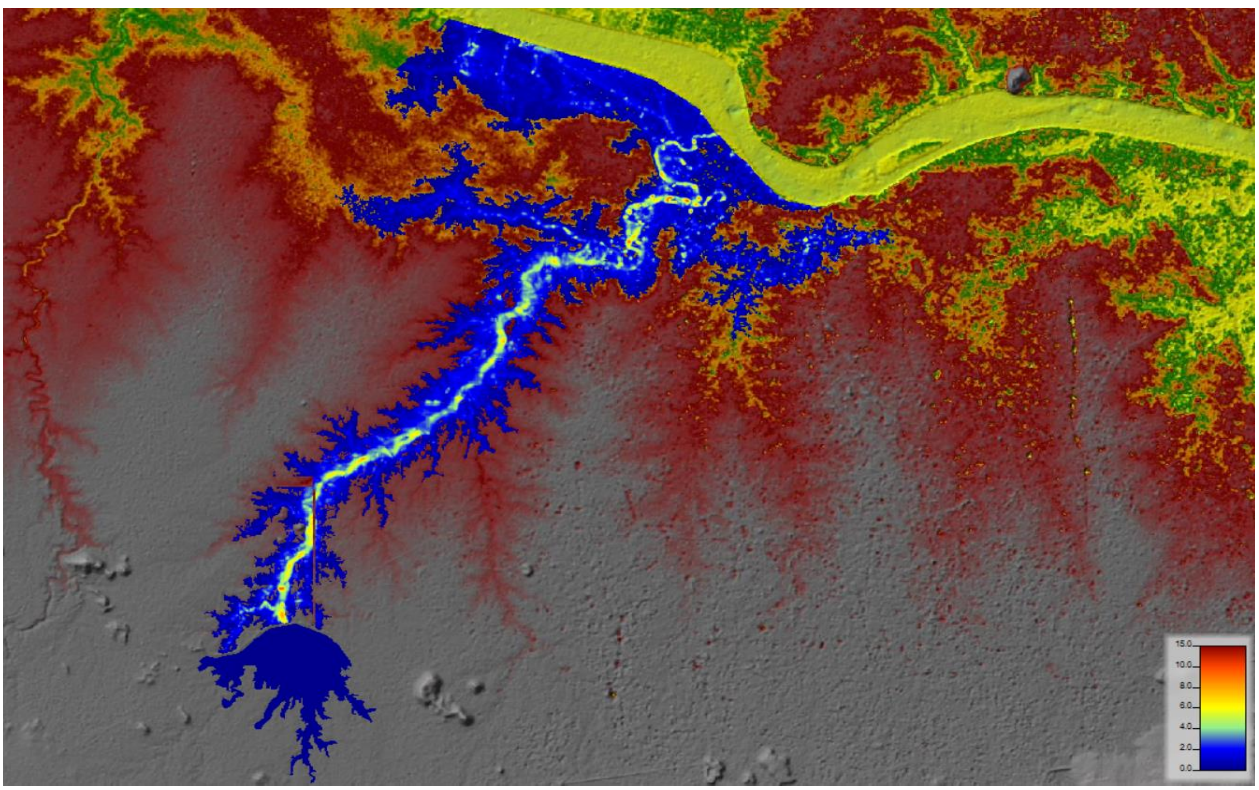


Figure:- 4.11 Velocity for Overtopping On Gunta river (Ras Mapper)

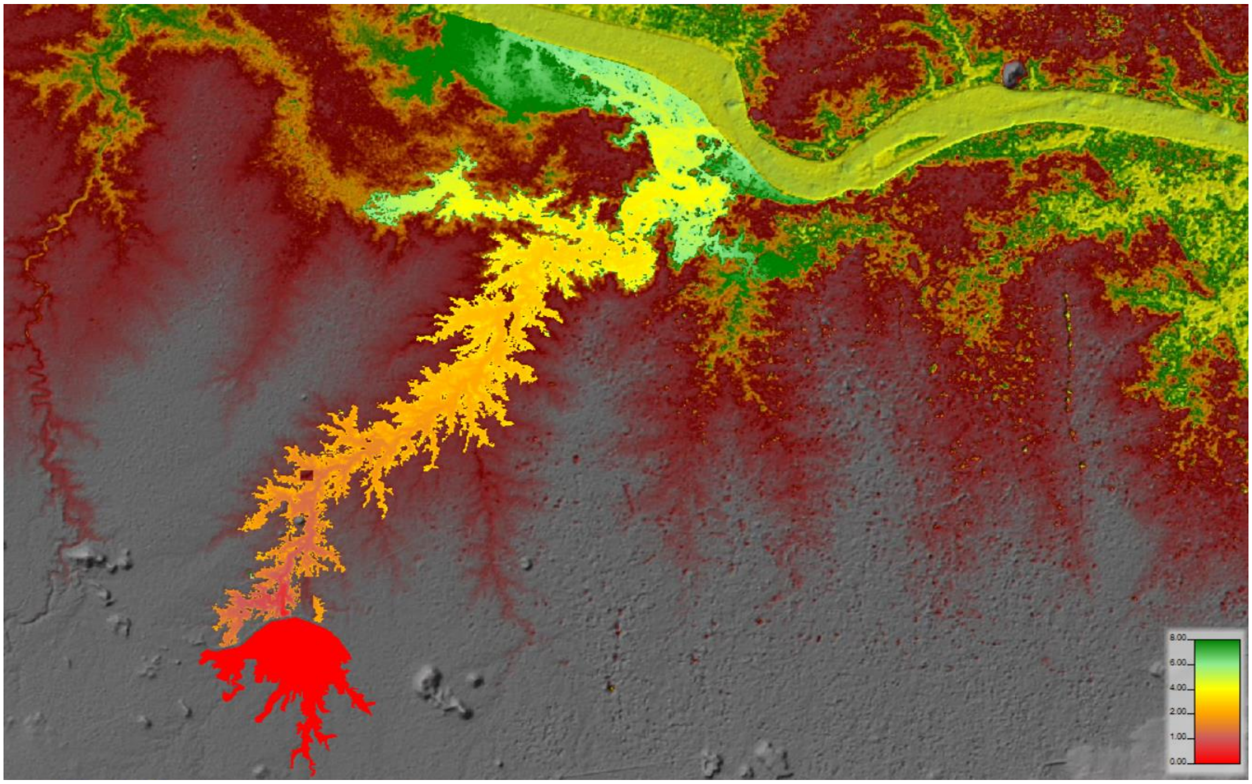


Figure:- 4.12 Arrival Time for Overtopping On Gunta river (Ras Mapper)

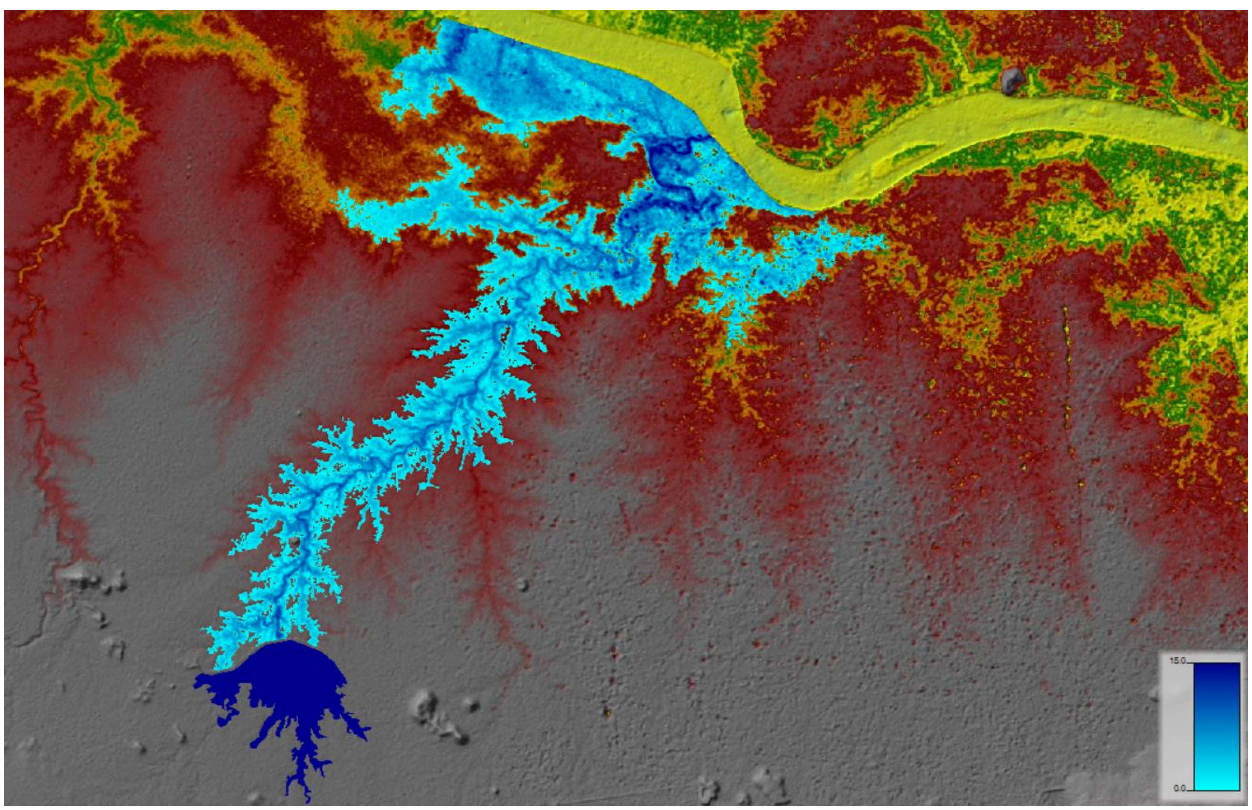


Figure:- 4.13 Depth for Overtopping On Gunta river (Ras Mapper)

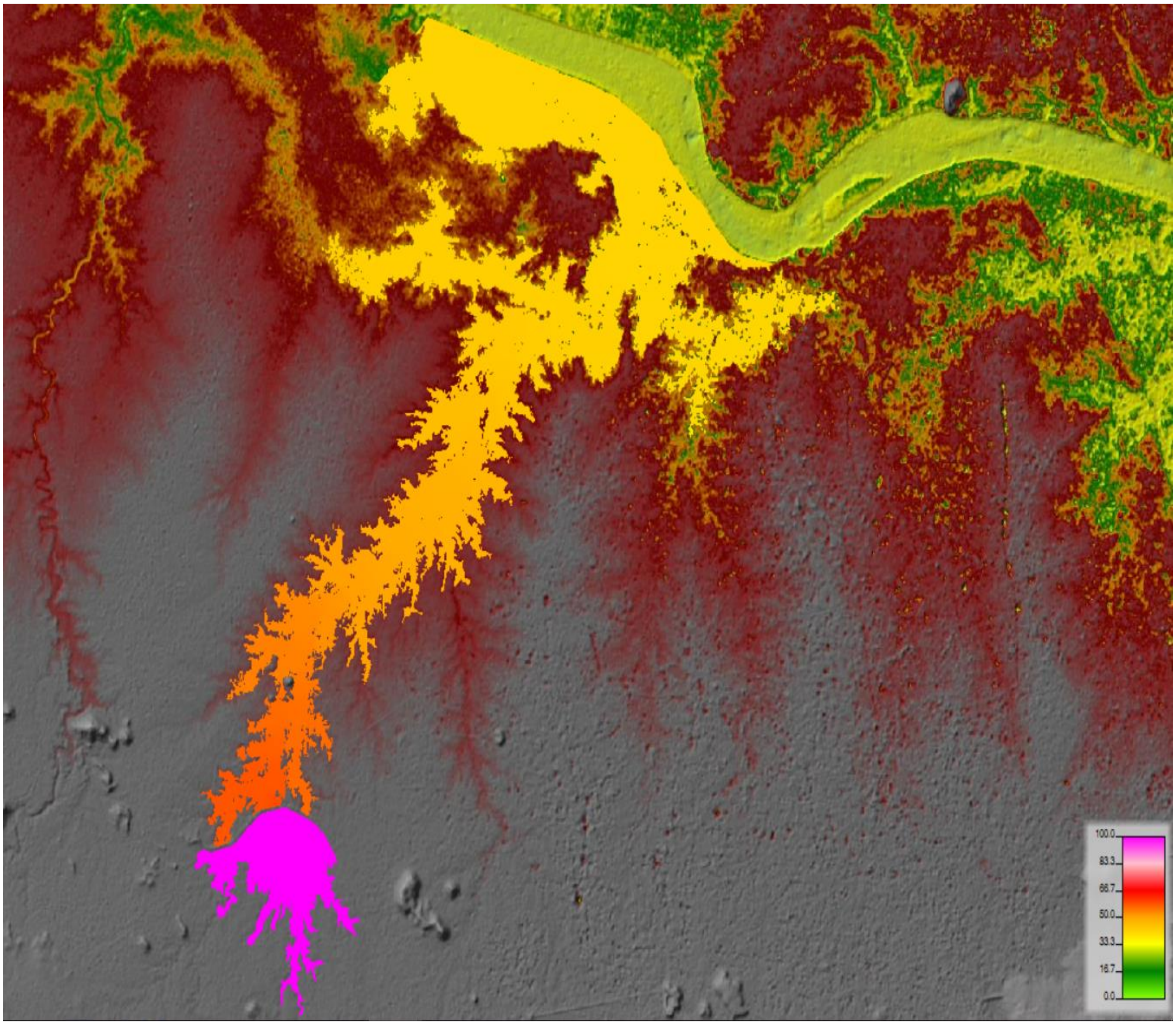


Figure:- 4.14 WSE for Overtopping On Gunta river (Ras Mapper)

4.4 Flood Inundation Mapping of Overtopping and Piping

Using the breach outflow hydrograph resulted from HEC-RAS model, downstream flood inundation extent and depth is delineated and mapped in order to differentiate the flooded areas in depth and area.

The model results gave a flood depth 41.29 m as the minimum to a critical height of 33.84 m for the catchment(overtopping) whereas flood depth 39.80m as the minimum to a critical height of 33.84 m for the catchment(piping) (see Figure 4.10 to 4.14). In general, high water depth occurred along the main channel and spreads gradually to the floodplains. This can be attributed to the fact that the river has some small of tributaries which contributes to high inflow into the main channel. Also the river flows in between slightly hilly terrain and, as such, rain water uphill flows rapidly into the river channel. The inundations map for both overtopping and piping failure scenarios have been done and shown as follows. The inundation map Prepared due to PMF (hydrologic failure) represents overtopping and piping failure scenarios of Gunta River. The significant failure scenario which leads large flood plain according to the study result is the overtopping one. The inundation map for both failures has been shown as follows in figure and which is mostly representative for the study case.

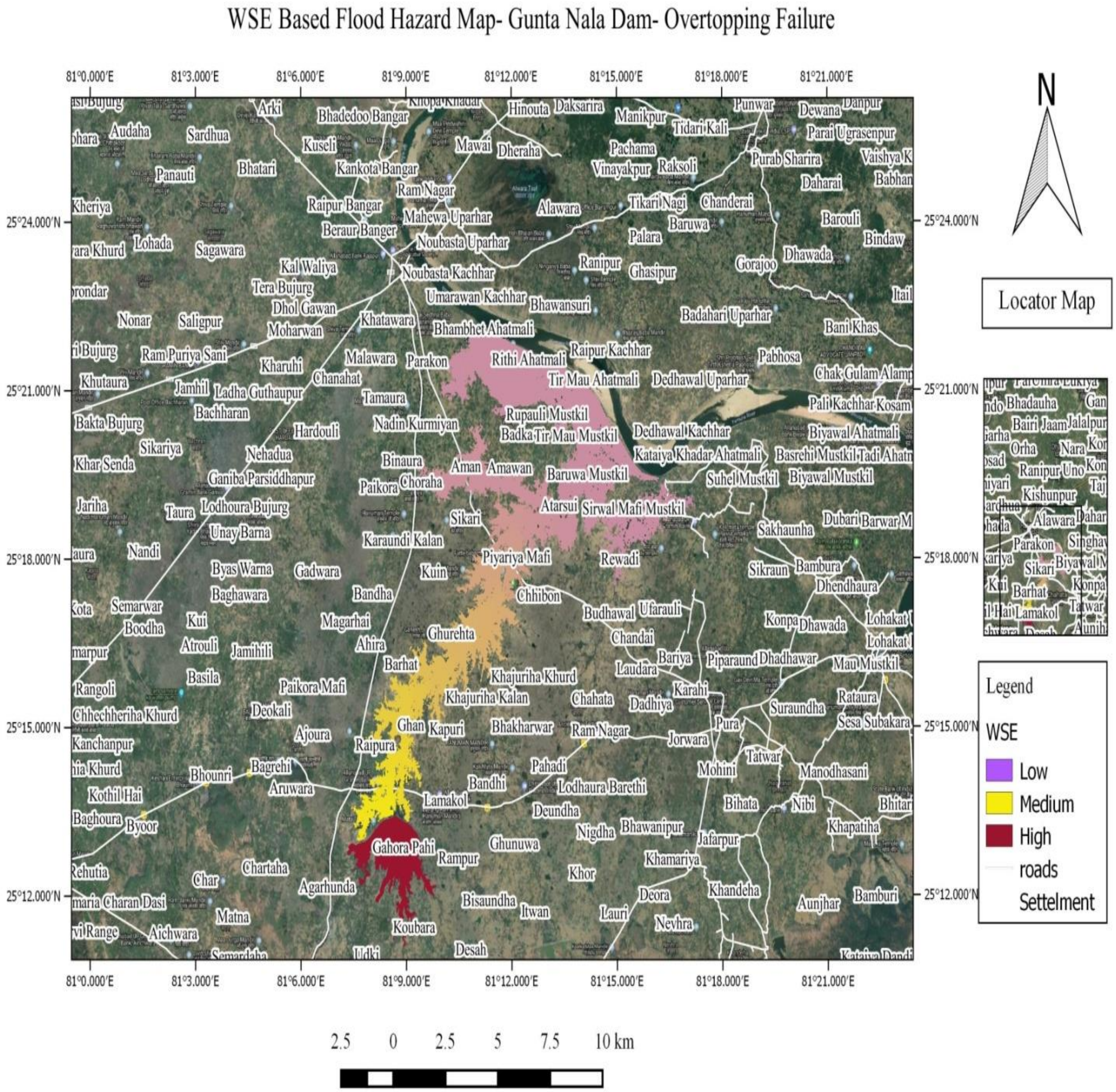


Figure:- 4.15 WSE Based Flood Hazard inundation Map of Gunta Nala Dam for Overtopping

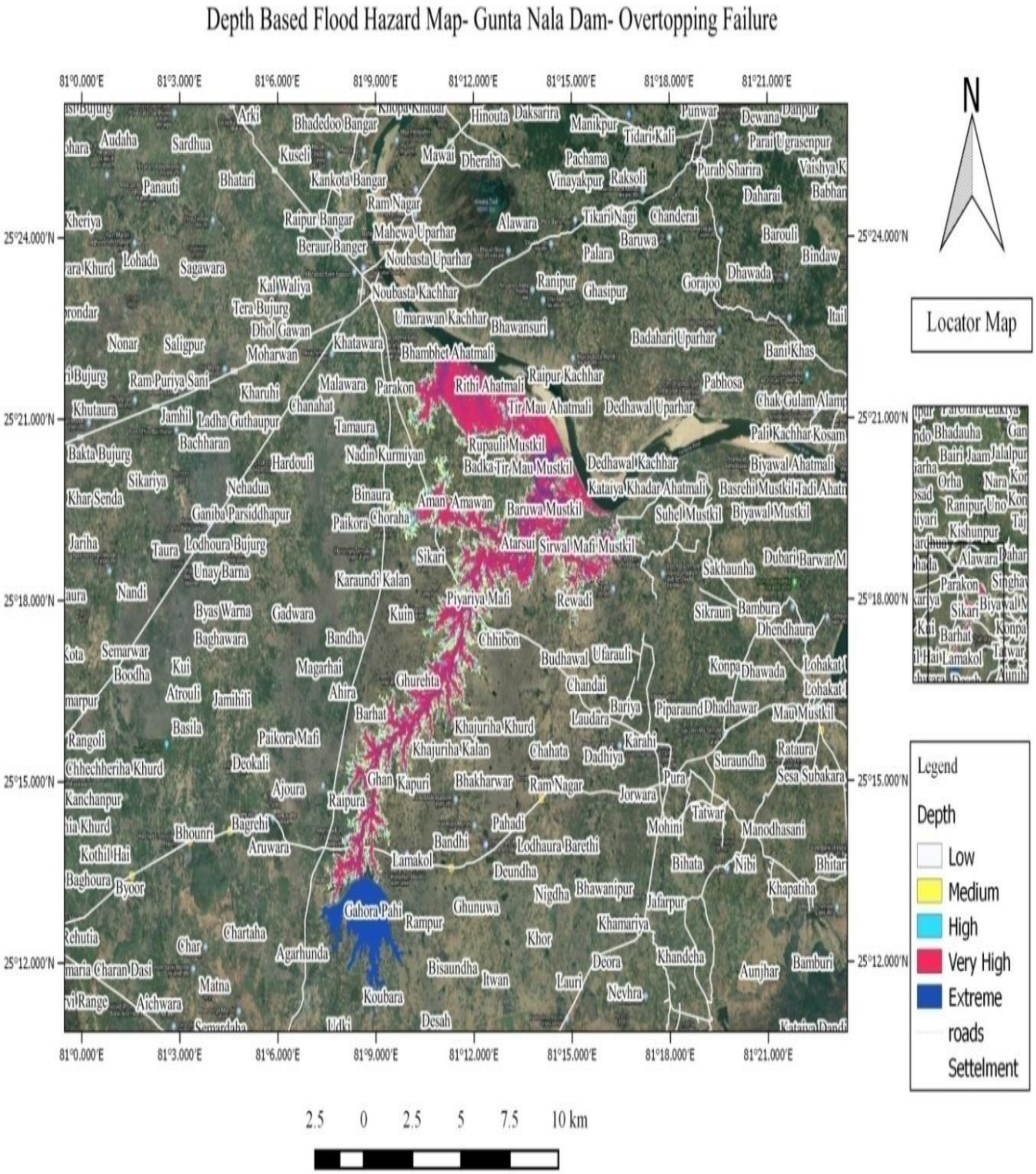


Figure:- 4.16 Depth Based Flood Hazard inundation Map of Gunta Nala Dam for Overtopping

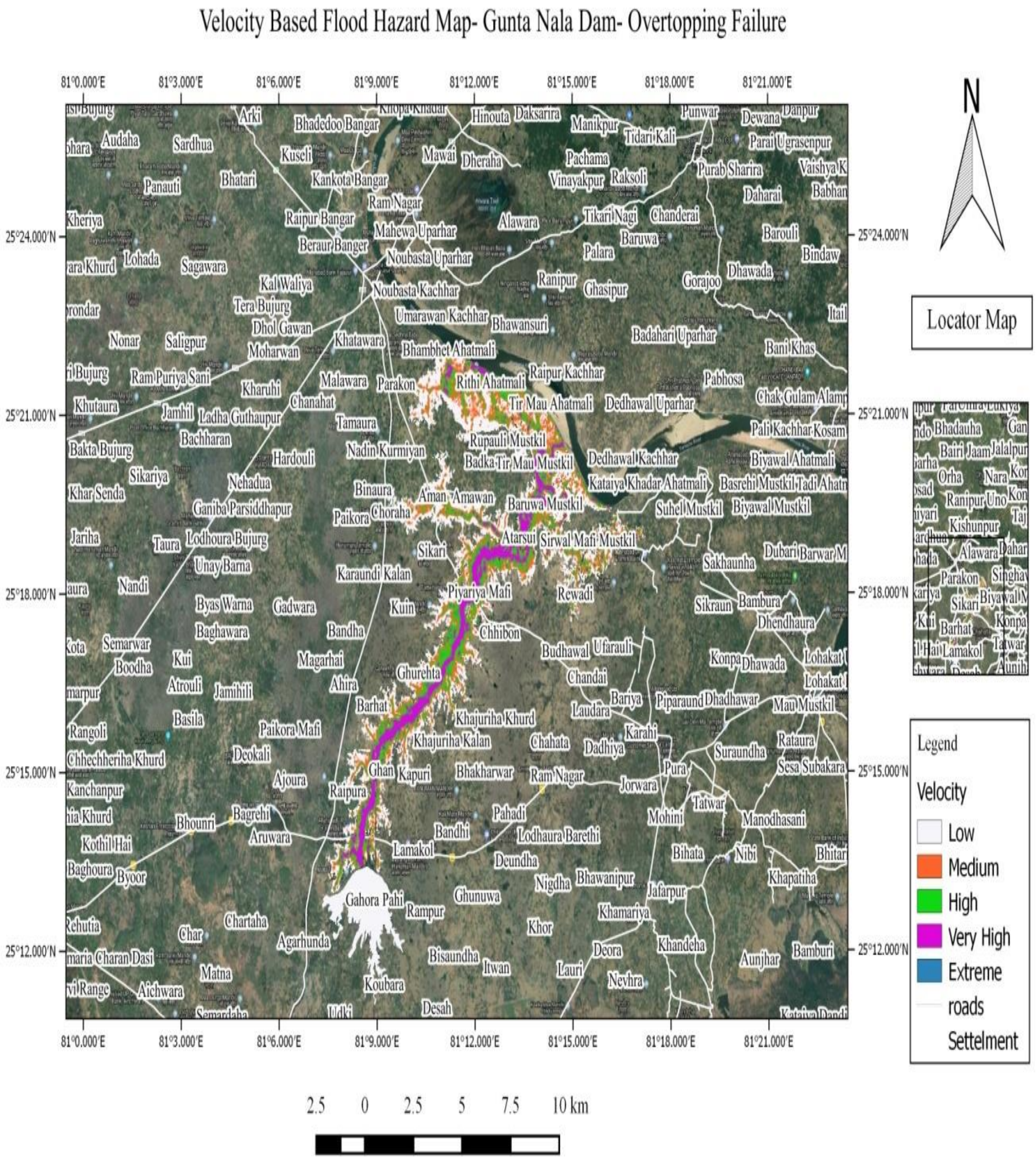


Figure:- 4.17 Velocity Based Flood Hazard inundation Map of Gunta Nala Dam for Overtopping

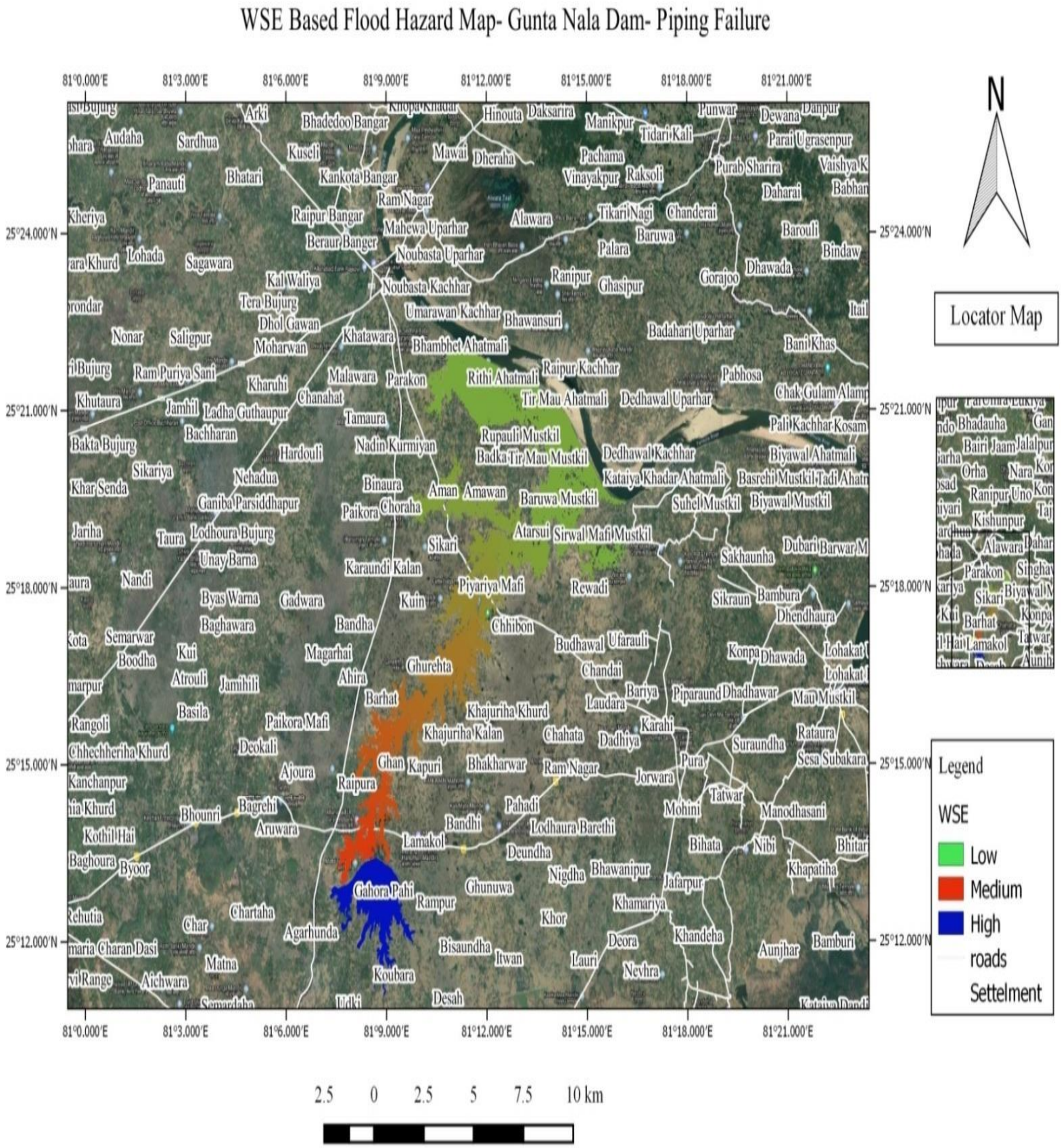


Figure:- 4.18 WSE Based Flood Hazard inundation Map of Gunta Nala Dam for Piping

Depth Based Flood Hazard Map- Gunta Nala Dam- Piping Failure

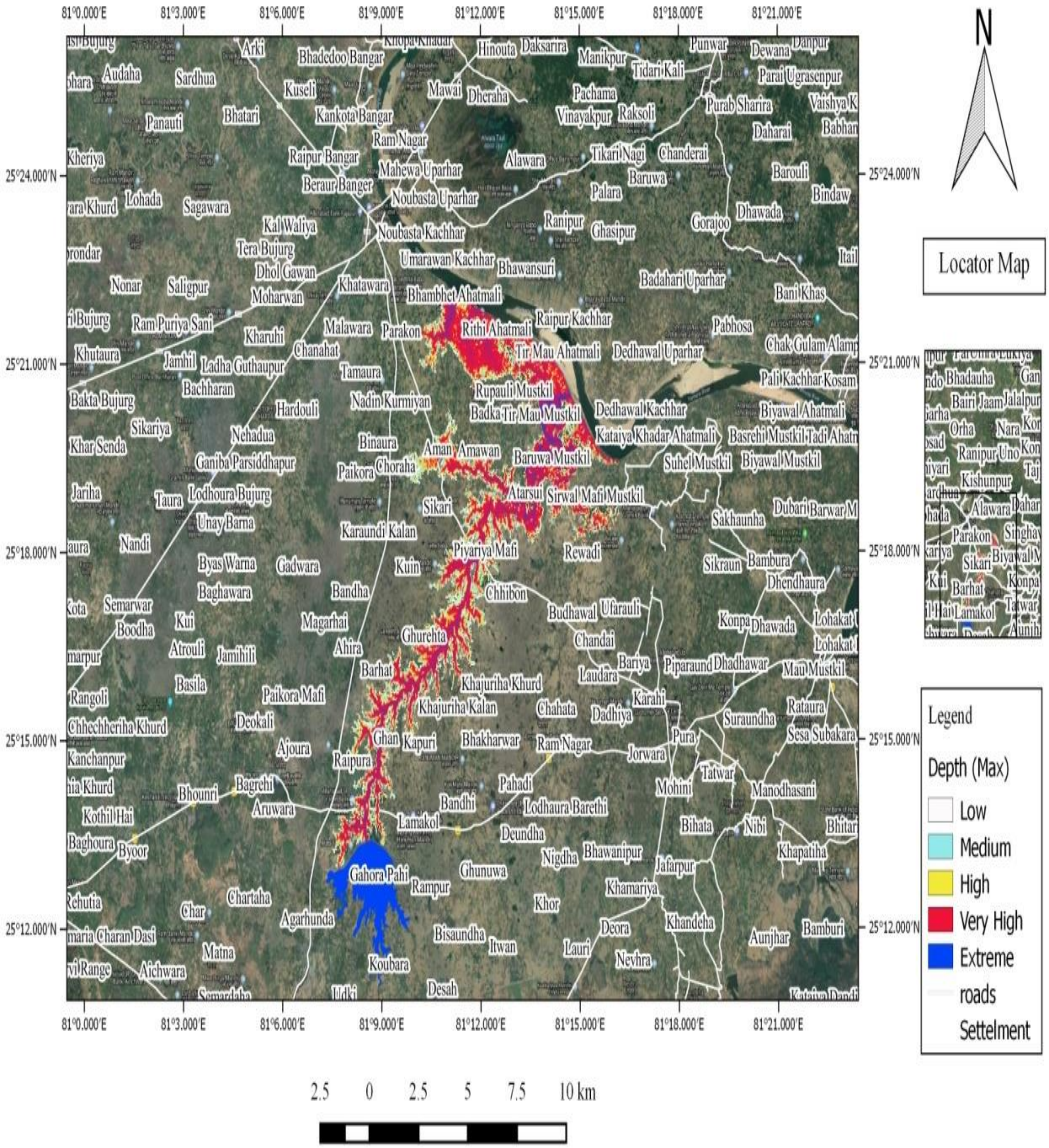


Figure:- 4.19 Depth Based Flood Hazard inundation Map of Gunta Nala Dam for Piping

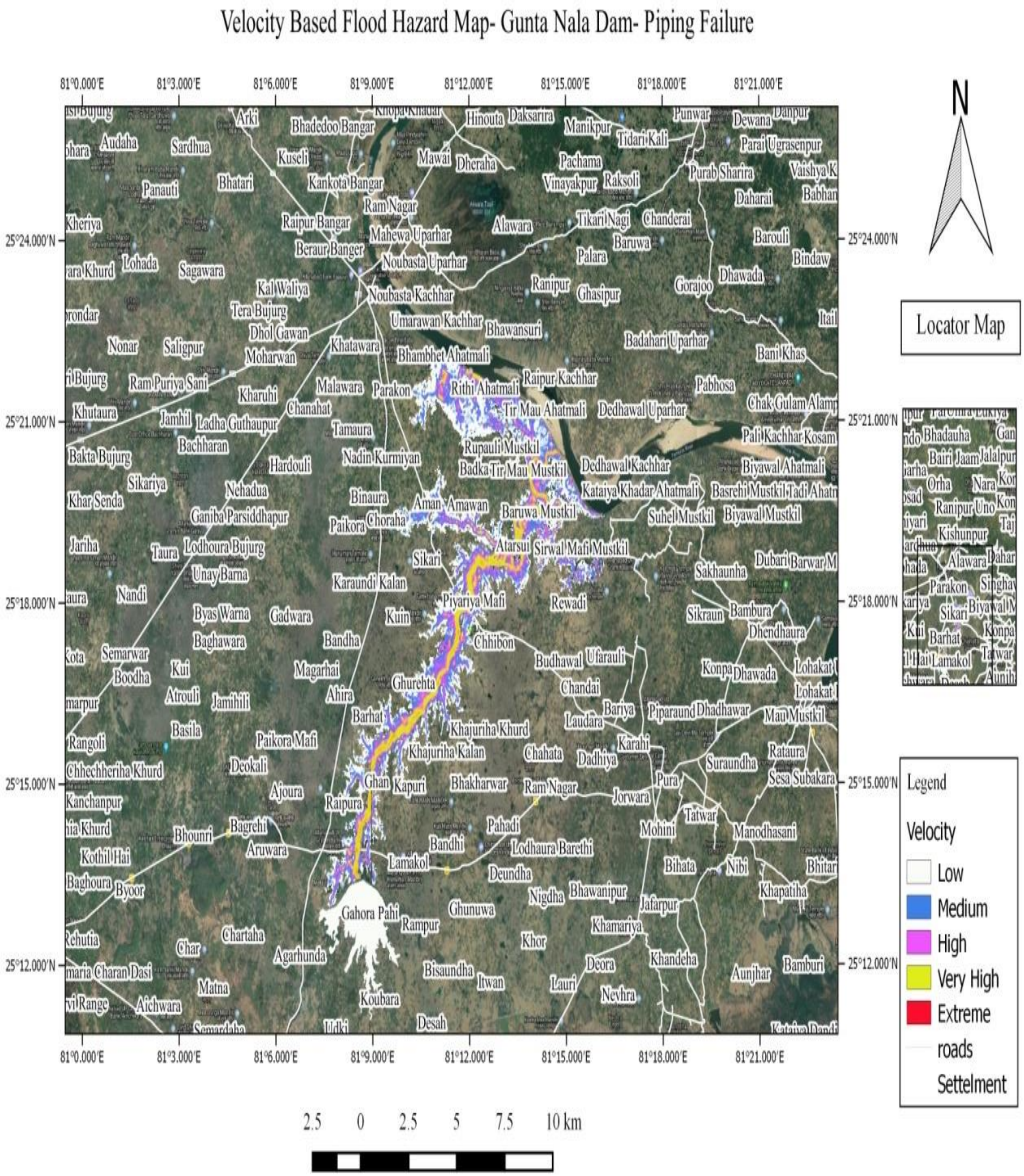


Figure:- 4.20 Velocity Based Flood Hazard inundation Map of Gunta Nala Dam for Piping

According to study result the inundation map for piping failure looks like the following. The piping failure has low significances when we compare to overtopping failure. The inundation map and failure scenarios give direction for emergency action plan.

4.5 Villages at Down Stream along Gunta River

Villages are located at downstream along Gunta river by Physical survey and with help of map coordinate app. The Villages details are Showsin Table no. 4.3 and table- 4.4, village elevation, water surface elevation on river and arrival time at villages.

The results of the flood inundation mapping from Gunta Nala Dam breach analysis indicates that much of the severe flood inundation occurs after 0.4 km and 0.9 km downstream of the dam and arrival time is 25&30 minutes for overtopping & 45&65 minutes for pipingat GohraPari and Raipura village respectively where large Agriculture field is found in the left and right side of the river, and at 12.6 to 23.8 km downstream where a small town Chhibonis located at 12.6km downstream of the dam& arrival time is 105 minutes for overtopping and 140 minutes for piping respectively.Some villages are PiyariyaMafi, ManaudhaMafi, Atarsui, Gobraul, Bhawanipur, Tir Mau and RupauliMustkil which are totally inundated are located as shown in figure 4.10 and 4.12 above and table- 4.5 shows WSE and arrival time. The PMF event indicates that there will be coverage of large irrigation field 25 km downstream of the dam where large left and right irrigation field are found with the ranges of flood depth from 0-19.39m. In addition to this, the two bridges are found on Banda to Prayagraj highway at 950 meters downstream of the dam and Lalta mod to Rajapurhighway at 13.5km downstream of the dam is also totally submerged by breach outflow flood&arrival time is 30 minutes and 115 minutes respectively. Finally, concluded in this result overtopping failure is very danger compare to piping failure.

Table No.- 4.2 Villages at Downstream of Gunta Nala Dam

S. No.	Village Name	Distance From Dam m	Distance From River m	Side From River
1	GohraPari	400	225	Left
2	Raipura	950	100	Left
3	Dhan	3100	100	Left
4	Singhpur	6200	100	Left
5	Ghurehta	8200	512	Left
6	Amarpur	9000	182	Left
7	Chhibon	12600	100	Right
8	PiyariyaMafi	13800	200	Left
9	ManaudhaMafi	14000	500	Left
10	PiyariyaKhurd	15100	500	Left
11	Aman	15500	2000	Left
12	Atarsui	17800	200	Left
13	Gobraul	17900	300	Right
14	Baruwa	18800	100	Left
15	Bhawanipur	19200	100	Left
16	UmriBehat	22800	240	Right

17	Tir Mau	23100	700	Left
18	RupauliMustkil	23800	1800	Left

Source:- Physical Survey with help of Map Coordinate App

Table- 4.3 Village Elevation, WSE and Arrival time at Villages

				WSE Max in meters		Arrival Time in minutes	
S. No.	**Village Name**	**Distance From Dam m**	**Village Elevation m**	**Piping**	**Overtopping**	**Piping**	**Overtopping**
1	GohraPari	400	107-114	57.8	58.32	65	30
2	Raipura	950	97-116	57.3	57.78	45	25
3	Dhan	3100	100-110	53.61	54.15	75	45
4	Singhpur	6200	99-109	49.87	50.39	90	55
5	Ghurehta	8200	105-106	48.29	48.77	95	60
6	Amarpur	9000	98-102	47.88	48.29	115	85
7	Chhibon	12600	91-105	44.75	45.17	140	105
8	PiyariyaMafi	13800	97-103	43.5	43.96	150	115
9	ManaudhaMafi	14000	97-100	43.35	43.83	180	145
10	PiyariyaKhurd	15100	92-102	42.49	43.05	205	165
11	Aman	15500	98-101	42.03	42.74	275	235

12	Atarsui	17800	97-101	41.09	42	200	170
13	Gobraul	17900	93-98	41.06	41.99	310	240
14	Baruwa	18800	96-103	40.92	41.9	230	195
15	Bhawanipur	19200	97-103	40.7	41.79	255	215
16	UmriBehat	22800	91-99	35.85	41.31	280	235
17	Tir Mau	23100	93-101	39.84	41.31	260	220
18	RupauliMustkil	23800	91-102	39.8	41.29	380	315

Source:- Map Coordinate App and HECRAS Results

CHAPTER-5

CONCLUSION AND RECOMMENDATION

5.1 Conclusions

The significant dam breach analysis of Gunta Nala embankment dam is simulated through HEC RAS as model for the hazards classification as thesis work. The impact of dam break over entire area both by piping and overtopping mode are observed in terms of flood hydrograph and flood prone area. The rate of changes in peak flow for over topping failure is not uniform and ranged between 5000 CMS to about 7000 CMS.

According to the result obtained through regression method using Froehlich-2008 the breach bottom width for overtopping event is 88m. Whereas the formation time for overtopping is 1.49 hrs (Froehlich-2008). In similar manner the bottom breach width for piping is obtained as 69m using Froehlich-2008. As results of HEC-RAS Model simulation shows, the peak discharge of 6462.86m^3/s for overtopping and 4943.88m^3/s for piping respectively.

The Breach outflow flood from HEC RAS model shows that the inundated areas ranges from a depth of 0.0 to 19.91 m in the case of overtopping failure. Flood depth for piping was 0.0 m to 14.23 m Due to this, high water depth occurs along the main channel and spreads gradually to the floodplains. The study result show that overtopping failure mode is more risky compared to piping failure. Major settlements are located downstream of the dam and settlements will be affected due breach.,

The maximum breach outflow discharge for overtopping is 6462.86m^3/sec and peak breach out flow discharge for piping is estimated at 4943.88m^3/sec respectively.

- The villages of GohraPari and Raipura will be affected by flood within 30 minutes for overtopping and 65 minutes for piping respectively. Emergency evacuation should be undertaken within 30 minutes.

- The peak flows in the channel is highly sensitive to a minor change in channel bed slopes, i.e. as the channel bed slopes became flatter and the peak flows became higher.

5.2 Recommendations

It is recommended that the Department of water resources Govt. of Uttar Pradesh undertake dam breach studies for all dams of UP to avoid disaster and prepare disaster management plans.

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